Solution slots or ice-wedge casts?

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SOLUTION SLOTS OR ICE-WEDGE CASTS?

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ABSTRACT

Several types of wedge-shaped and graben-like deformations in loams and terrace deposits at Maastricht-Belvédère show some striking similarities with ice-wedge casts. Normal faulting, vertically dressed pebbles and infilling by flow and downfall are characteristic. Comparison with a typical ice-wedge cast from the same region stresses the absence of a vertically laminated central part in the deformation structures at Maastricht-Belvédère. It is concluded that wedge-shaped and graben-like features at Belvédère are caused by slot solution in the underlying chalk subsoil.

INTRODUCTION

Wedge-like downsinking structures are striking features on top of and in the Caberg terrace at Maastricht-Belvédère. They are piercing the terrace deposits and are filled with overlying loams. Their general form resembles ice-wedge casts. On the other hand circular hollows are frequently observed in the top of the terrace gravels and in the underlying coarse-grained Palaeocene chalk. The latter rock is very appropriate for dissolution and a karstic origin for the circular hollows is obvious. The interpretation of the deformation structures is important for the characterisation of the palaeoenvironment. In order to check the hypothesis of the deformations at Maastricht-Belvédère to be ice-wedge casts a comparison is made with typical ice-wedge casts formed in loess outside the chalk area.

DESCRIPTION OF THE DEFORMATION STRUCTURES IN THE TOP OF THE CABERG TERRACE AT MAASTRICHT-BELVÉDÈRE

Small graben-like or wedge-like forms occur frequently in the Belvédère pit at Maastricht. Their width varies from a few decimeters to several meters. The top of the disturbances is situated within the 'Loams' (Unit 5; see Vandenberghe et al., 1985). The deformation structures pierce through the 'loams' and fluvial sands (Unit 4) down into the terrace gravels (Unit 3). Whether they penetrate the underlying subsoil as well could not be observed.

In order to investigate the characteristics of the concerned structures three examples are described in detail.

In a first form (fig. 1) the wedge is sharply limited at the boundary with the surrounding fluvial sands. This limit is continuous and shows no interruptions by faulting. The wedge is filled with 'loams' which gradually and regularly have sunk downward. Movement is sometimes accompanied by downfaulting. The central part of the wedge consists of the uppermost part of disturbed sediments, in this case material derived from the B2t-horizon of the Rocourt-soil. The exterior part of the wedge is composed of dark-brown, clay-enriched 'loams' normally occurring below the Rocourt-soil. A smaller 'adventive' wedge also shows sharp boundaries and the same type of small normal fault at its southern edge marks the limit of the global sinking structure. The small edge may be explained as a tensional crack accompanying extension faulting. The upper part of frost fissures, which are posterior to the Rocourt-soil, have been moved towards the centre of the depression.

A second type of perturbation is a graben structure with similar characteristics but formed entirely in the terrace gravels (fig. 2). Its large width is caused by a series of extension faults. Although a step-like structure is obvious, the layering is almost continuous along the fault planes as well as in the centre of the structure.

A third kind of deformation is also formed within the terrace gravels. It shows vertical dressed stones at the edges (fig. 3). The vertical layering is due to infilling of the fissures along the fault planes. In the central part, however the orientation of the pebbles is random due to flow from the sides or horizontally directed due to vertical subsidence of cohesive blocks of the gravel unit.

Although apparently variable, the three kinds of perturbations show a few common characteristics. The central subsided part shows a complete absence of vertical lamination. Its original layering is conserved in the case of soil fall while homogenisation is due to processes of flow into a relatively wide depression. Secondly, the sides of the wedge are sharply limited by uninterrupted boundaries.

ICE-WEDGE CAST AT NAGELBEEK (Southern Limburg)

A nearby outcrop in thick loess deposits (Vreeken & Mücher 1981) allows the comparison with wedge forms of clearly periglacial origin. Within the Upper Silt Loams corresponding to Unit 7, ice-wedge casts are formed (Meijs et al. 1983). One of them is represented in fig. 4. Its upper part consists of a downward directed involution of more than 0.80 m (the original top was no more visible). The internal section of the lower part is composed of vertically laminated Upper Silt Loams. They are penetrating into the Middle Silt Loams (Unit 6) which are fractured by a series of extension faults. This zone of fracturing forms the exterior section of the lower part of the wedge. The depth of the lower part is about 2 m. The described subdivision in different parts and their respective structures are typical for ice-wedge casts (Vandenberghe, 1983a). Especially the vertical lamination in the centre of the lower part is a characteristic feature. It originates from the infilling by muddy sediments between the ice core and the wedge sides.

The ice-wedge has pierced the Eltville tuff layer and the greyish involuted Nagelbeek horizon. It is filled with Upper Silt Loam, while several meters of Upper Loess are covering the ice-wedge cast (Meys et al., 1983). It follows that, according to the age of the Eltville tuff (Semmel, 1967; Wintle & Brunnacker, 1983)

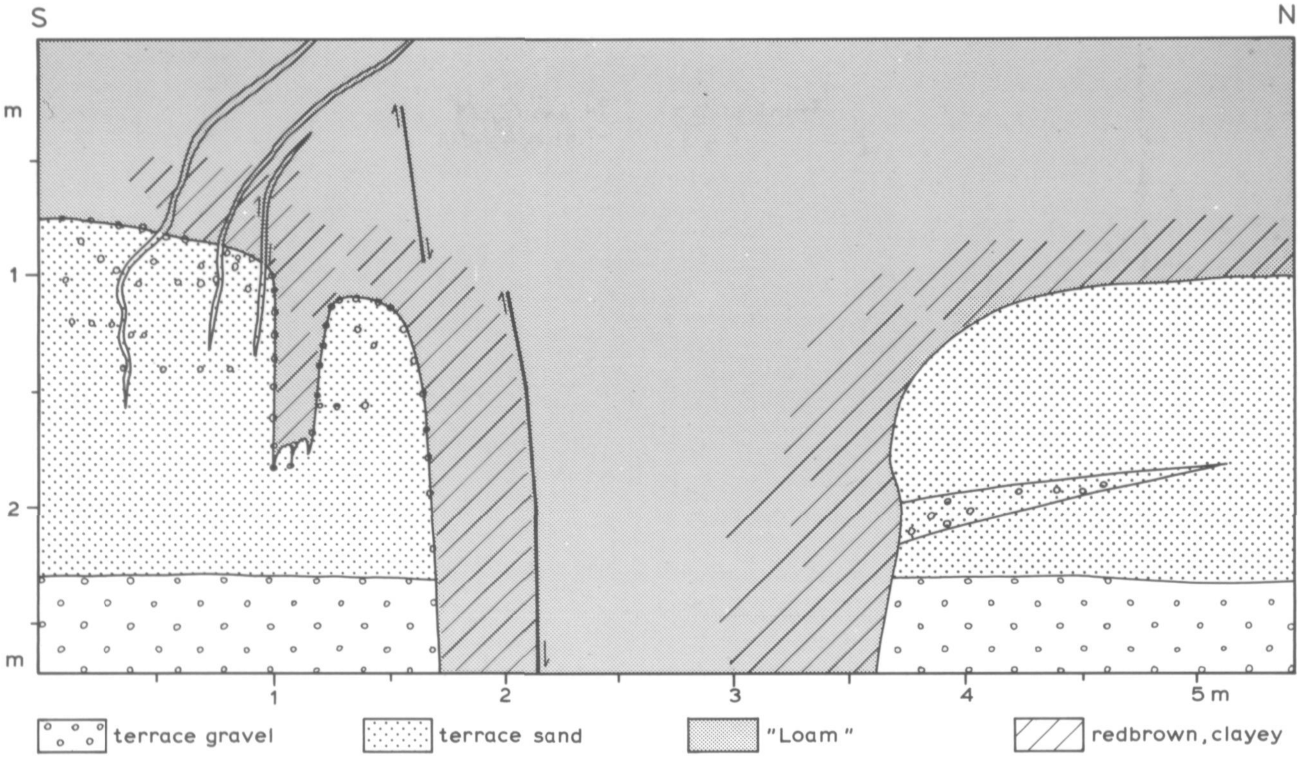

Fig. 1. Wedge-shaped structure within the 'loams' and terrace deposits (westside of the Belvédère-pit; top of the section is at ca 55 m + NAP).

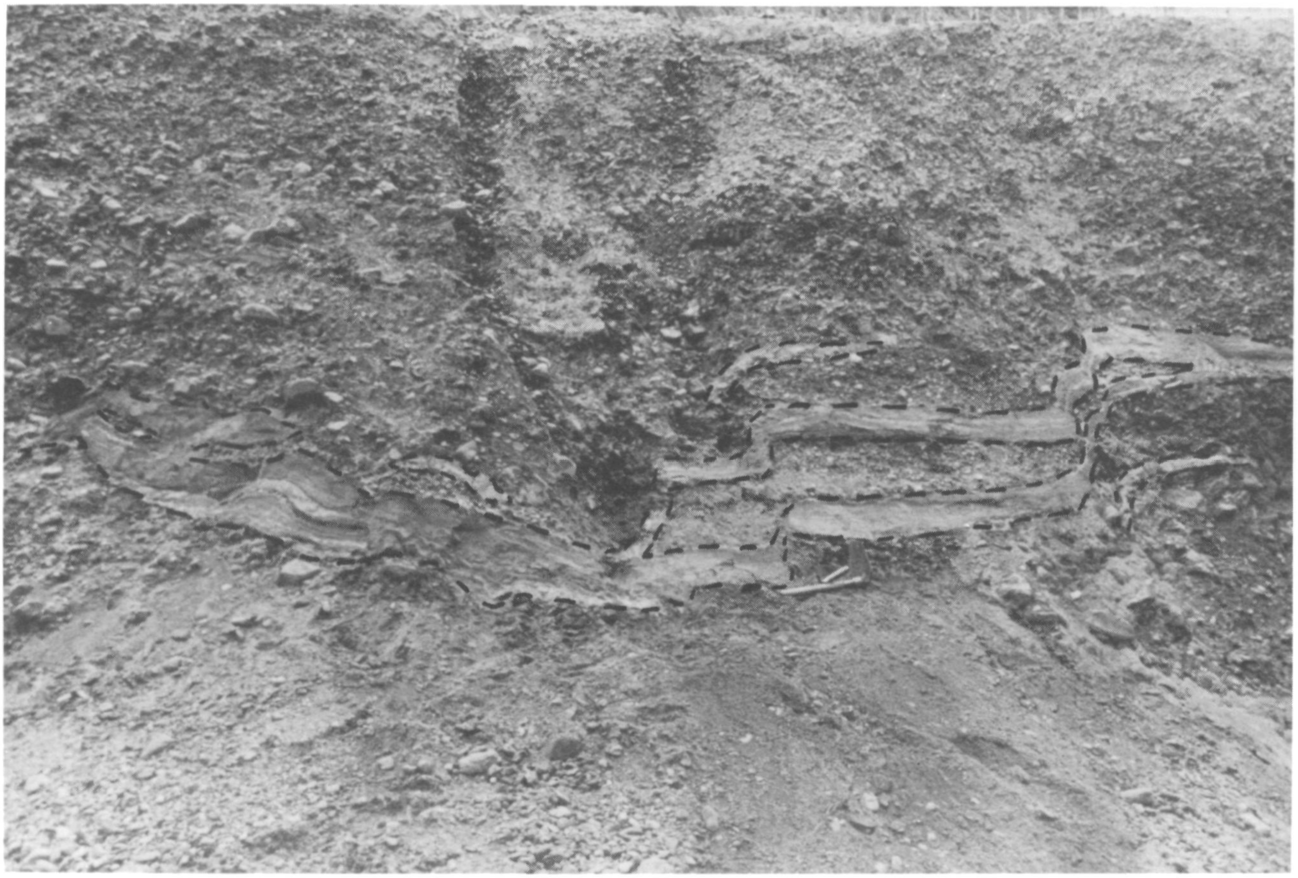

Fig. 2. Downfaulted deformation structure within the terrace gravels of the Caberg terrace (Belvédère-pit). The length of the shovel is 55 cm.

and the Kesselt soil B (Gullentops in Haesaerts et al., 1981; Gullentops, 1981) which is an equivalent of the Nagelbeek horizon, the ice wedge has been formed slightly after 21.000 yr B.P. The ice wedges at Nagelbeek correspond to the widely occurring level of ice wedges which have developed at that time (Vandenberghe, 1983b).

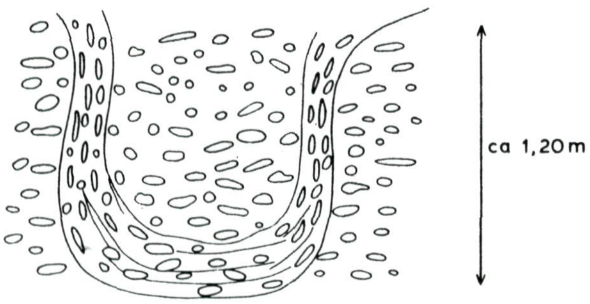

Fig. 3. Pocket-shaped downsunk structure within the terrace gravels of the Caberg terrace (Belvédère-pit).

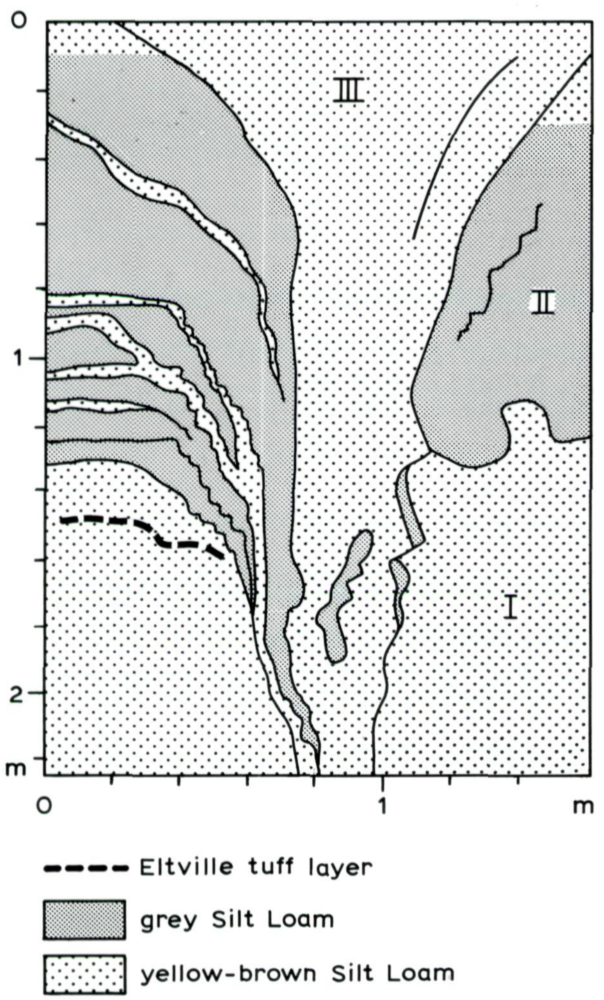

Fig. 4. Weichselian Upper Pleniglacial ice-wedge cast at Nagelbeek. I = Middle Silt Loam, II = Nagelbeek Horizon, III = Upper Silt Loam. The 0 m level is at ca 117 m + NAP; for situation see: Meijs et al. 1983.

COMPARISON OF THE SUBSIDENCE FEATURES AT BELVÉDÈRE WITH ICE-WEDGE CASTS

The deformation structures at Belvédère show some striking differences with ice-wedge casts:

a. The typical bipartition of the lower part of ice-wedge casts in a central and an exterior zone has never been found in the Belvédère subsidence features. The latter are characterized by sharp boundaries while locally present faults occur both near the edges and in the central part of the deformaion. In the ice-wedge casts, however, faulting is limited to the outer part. This results in transitional boundaries as is well illustrated at Nagelbeek (fig. 4).
b. The vertical lamination in the central lower part of ice-wedge casts is not always distinctly expressed in loess deposits. However, it is completely absent in the deformations at Belvédère. There the only vertical layering is present along the steeply faulted boundaries of some of these structures (fig. 3). Generally, the main part of the infilling is homogenized by slumping into the wedge-shaped openings. In other cases the total downsinking is effectuated by multiple faulting without any vertical layering in the centre of subsidence. Consequently the complete deformation (and not only the exterior part) takes the form of a graben.

Thus the subsidence features at Belvédère are filled by graben-like blockfaulting or by downslumping. The presence of tensional structures can easily be explained by any subsidence. They may show some similarity with ice-wedge casts (Black, 1983). Most remarkable is the complete absence of a central vertical layering which is, in the ice-wedge casts, caused by gradual melting of the ice cover accompanied by simultaneous infilling from the sides. The infilling by vertical fall as well as by flow from the sides obviously occurred in a short time over the total width of the cavity. Moreover, the deformations at Belvédère show a considerable heterogeneity of forms and of filling sediments. Finally they are unequally distributed over the area in contradiction with regularly developed ice-wedge polygons.

It may thus be concluded that the wedge forms on the Caberg terrace at Belvédère are no ice-wedge casts. By analogy to the circular hollows, which clearly have a karstic origin, the observed longitudinal wedge forms may be caused by solution of $CaCO_3$ along joints in the Palaeocene chalk. The observed karstic features are formed at several times between the end of the terrace formation and the formation of the Nagelbeek-horizon. Besides, favorable conditions for karstic processes were only present after lowering of the water table, it means from the incision of the Maas in the terrace gravels onwards.

CONCLUSIONS

In the Belvédère outcrop funnel-shaped sinks in the gravels of the Caberg terrace are obviously due to solution of the underlying Palaeocene chalk. On the other hand, wedge-shaped forms show at first glance some similarity with ice-wedge casts. Their internal structure, however, points to tensional cracking and filling by inflow from the sides. The characteristic vertical laminition of the lower central part of ice-wedge casts is completely absent in the deformations at Belvédère. Therefore the latter forms are interpreted as subsidence phenomena caused by slot solution of the joints in the chalk subsoil ('grikes'). The solution slots developed at different times during the deposition of the terrace sediments and overlying 'loams' up to the formation of the Nagelbeek horizon.

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