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THE HISTORY OF THE DEVELOPMENT OF A KARREN TROUGH BASED ON ITS TERRACES

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Abstract: A major karren trough in the Totes Gebirge (Austria) is being studied. Applying the theories of piracy (vertical beheading) and the origin of terraces the genetics of the various forms in the trough are classified and their development is sketched. The processes recognized in the trough offer facts for a better understanding of karren development.

1. Introduction

The area where the studied karren trough is located is situated in the Totes Gebirge mountains (Austria, the Salzburg Alps) at the bottom of a valley of glacial origin close to the Wiesenlacke Lake (*Fig. 1*). The ground surface that was formed rough by the glacier is now developing the karstic way. The mostly bedding plane surfaces are individual karren units that are separated by steps. These meso-karst units (*SZABÓ, L.* 1995) develop into more or less closed karst forms that *LECHNER, S.* (1953) refers to as half dolines (halbdolinen).

The karren trough - that is a major trough - in study developed on such a bedding plane surface dipping to south-east (*Fig. 2, Picture 1*). The trough is NW-SE directed, 6 m long, 0.8 m wide at its lower end and approximately 1.6 m at the upper end. It is deeper than 1.0 m at the lower end and this depth gradually falls under 0.5 m at the upper end. It forks at its upper end. Karren forms are absent in its immediate vicinity of several meters.

A detailed (scale 1:20) contour map was prepared of the trough. The interior forms (inner troughs, terraces and pits) are showed on the contour map of the trough.

Piracy with swallet development is typical in epigene karstic valleys (*JAKUCS, L.* 1968, 1971, *HEVESI, A.* 1978, 1984). According to *JAKUCS, L.* (1971) piracy occurs when the sediments covering the karst are not excessively impermeable while *HEVESI, A.* (1984) says it occurs in case the karstic water level is deeper than two meters under the limestone surface and the system of voids of solution origin is adequately developed. Due to the retreating of the sink points (*JAKUCS, L.* 1971) new swallets develop the earlier ones becoming sinkhole-dolines (*JAKUCS, L.* 1968, *HEVESI, A.* 1980).

Many observations prove that piracy occurs in the troughs of karren surfaces. During piracy pits or karren trough cavities develop (*VERESS, M.* 1995).

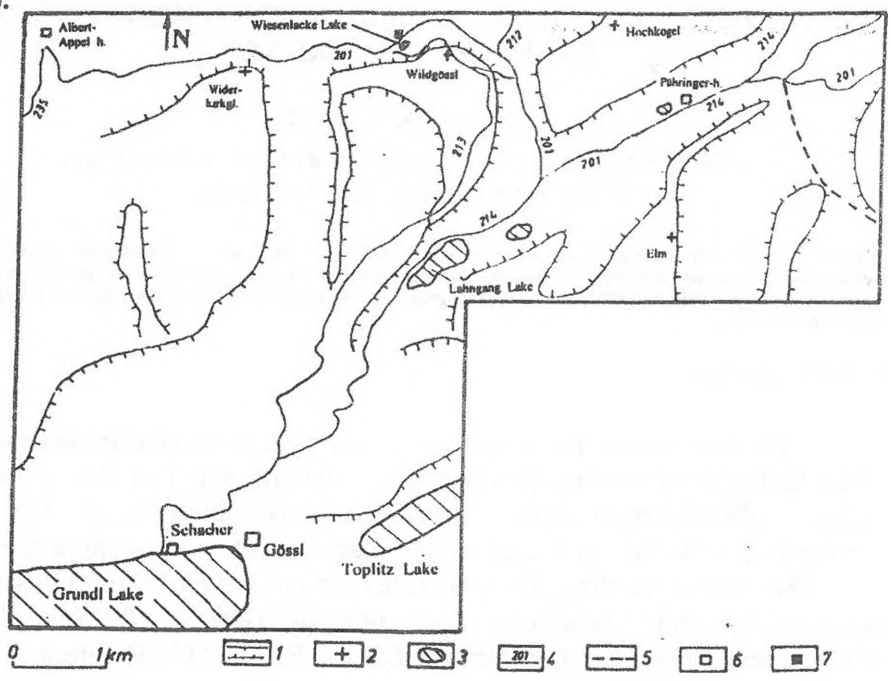


Fig 1: The study site in the mountains
Legend: 1: glacial valley, 2: summit, 3: lake, 4: hiker's track, 5: ski track, 6: hiker's hut, 7: study area.

Due to the above listed reasons piracy points could not develop in the trough bottoms because lacking a covering rock a lithographic interface is absent an active karstic aquifer and karst water table does not develop.

It is suggested that the piracy is due to the change of flow conditions of the solvent. The saturation of the solvent can be expected in the relatively deeply flowing solvent in the trough bottom if the flow is turbulent. In the case of laminar flow after an adequately short distance the stream reaching the point of sinking can remain unsaturated as only the volume of the solvent close to the rock surface is saturated. This can result the development of pits. At certain points the flow of the solvent can turn to laminar from turbulent if the gradient drops considerably (the velocity of the flow drops). The drop of the gradient of major troughs is a natural phenomenon as major troughs are definitely characterized by small bottom gradients.

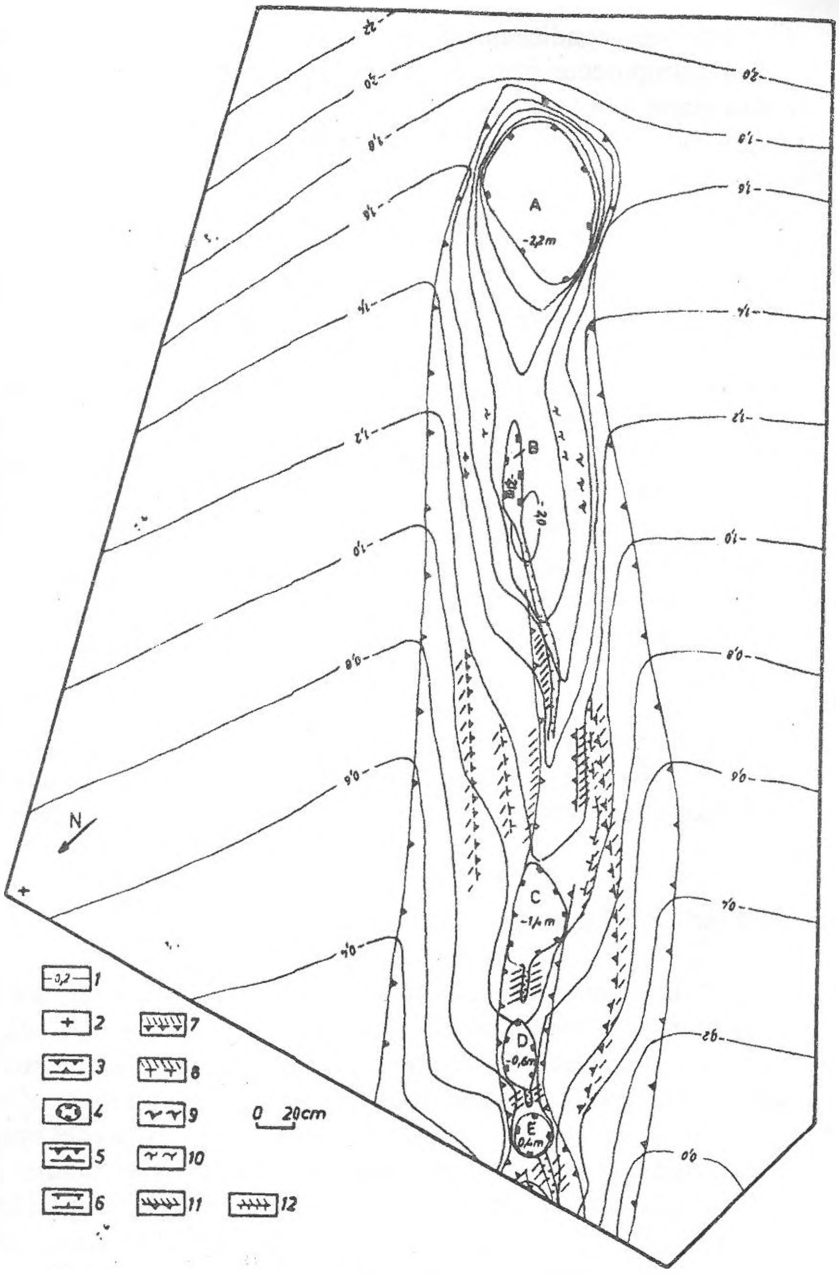


Fig 2: Contour- and morphological survey of the major trough
Legend: 1: arbitrary local contours, 2: position of the surveyor, 3: rim of the major trough, 4: pit, 5: type II trough of pit B, 6: type III troughs, 7-8: remnants of terraces of various elevation, 9-10: edges (remnants of terraces) of various elevation, 11: terrace, 12: terrace in development

The gradient conditions of the trough in study indicates that the decrease of the drop occur from the downstream parts of the trough towards the upstream parts. This attracts the extension of the laminar flow to the upper trough-end that can result the retreating of piracy (development of new pits).

Existing pits can promote the development of new pits. According to *WILLIAMS, P. W.* (1985) to pits - as to locations of minimal pressure - the water stored in the rock will collect. Supposedly the existing pits of a trough enhance the vertical movement of the water that promotes the development of further pits.

Karren terraces can develop in the troughs when the development of type II and type III troughs is quicker than that of the lateral development of the master trough. This way due to the widening of the inner trough only narrow strips of the master trough bottom remain. The initial condition of this phenomenon is a wide trough bottom. The development of trough bottom remains (terrace) can be due to the listed causes:

- The master trough loses its catchment area thus only that much solvent can flow in the trough steadily that allows only the development of type II and III troughs.
- The master trough can grow to such size that the solvent from the original catchment area fills it only partially.
- Piracy occurs in the trough bottom. Starting at the point of piracy further trough(s) develop that digest the bottom of the master trough in part during their regression.

2. The Morphology of a Major Trough

The pits in the master trough in study (henceforth trough) are typical piracy (water drainage) trough bottom pits. In the case of the B, C, D, E pits the piracy is proved by their development in the bottom or at the end of the inner trough. The drainage of water is proved by the development of type III troughs retreating from the pits. Possibly the A pit or its predecessor may have been a trough-end pit. This letter has lost its activity as neither type II nor type III troughs are connected to it. (The A pit could be specified as a trough bottom pit if the it were developed in the bottom of an inner trough or if the inner trough continued beyond the pit).

The retreating of the locations of the piracy occurred as the size of the pits decreases upwards from the lower trough end.

Two types of troughs can be specified in the bottom of the major trough (main trough). One of these types is represented by a type II trough that is the older regressive trough of the B pit (henceforth the type II trough

of pit B). To the other category type III troughs belong. The type II occupies a considerable part of the bottom of the master trough but is partially damaged and separated to parts by the C, D, E pits. Type III troughs are forms retreating from the B, C, D, E in the bottom of the type II troughs.

Remains of terraces can be identified between the B and C pits on two levels. (The upper No. 1 terrace stretches to pit E on the south side of the trough.) The remnants of the terraces are a couple of centimeters wide. (The remnant of the trough bottom at the north slope of the trough - the lower N° 2 terrace - exceeds 10 centimeters.)

Terrace No. 1 is the remnant of the trough bottom (major trough), terrace No. 2 is the remnant of the type II trough leading to pit A. Even the remnants of the terraces are now missing on the trough sides between the pits A and B. Only the remnants of edges can be identified in the same two levels.

In essence the terraces were wholly digested between pits A and B. In this phenomenon the development of pit B might have had a role or the recharge of solvent to the trough from its rims. Subsequent trough(s) could not develop from pit A as the catchment of this pit became too small after the development of pit B.

It can be stated with much certainty that the described remnants of terraces and edges are the remnants of these two terraces because 2-2 straight lines can be fitted to the edges of these two remnants on both sides of the trough. The troughs responsible for these terraces can not be observed beyond the lower end of the major trough and the straight lines fitted to the upper terrace remnants and edges touch pit A. The described fact hint that the terraces and the troughs that are responsible for them developed above and after the development of pit A. This proves as well that the development of pit A started after the development of the trough. In this case the major trough gradually changed to be a blind karren trough after its development (similarly to the blind valleys of karst areas).

The development of a type II trough resulted the development of a new terrace or is presently resulting it. This is terrace No. 3 that is the remnant of the type III trough leading to pit A. It is visible that because of the missing older terraces it develops only locally because there is no chance for this because of the ending of the above mentioned trough it can not develop between pits A and B. The changing of the terrace to a remnant can be observed on the south side of the trough in the section between pits B and C. This can be explained by the widening of the type II side of pit B reaching the type III side of pit A in a short section.

The development of a No. 4 terrace is in progress from the bottom of the type II trough of pit B at those places where type III troughs have developed.

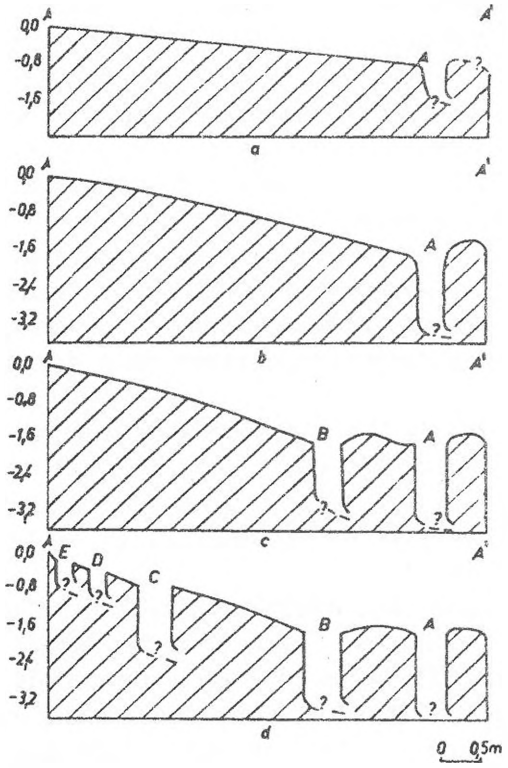


Fig 3: The history of the karren trough in profile

3. The History of Development of a Trough

The trough develops, then its A pit does (*Figures 3a, 4a*). Supposedly no surface drainage of the trough developed. The retreating and widening of the type II trough digesting most of the bottom of the major trough resulted the development of terrace No. 1. With the development of the type III trough of pit A the development of the No. 2 terrace begins. Then pit B develops followed by its type II trough (*Figures 3b, 4b*).

The widening of this type II trough digests the bottom of the type III trough belonging to pit A and results the No. 3 terrace. The development of a new trough (type III trough) commences from pit B. The change of terraces No. 1 and 2 to remnants occurs with the change of remnants to mere edges at certain sections (*Figures 3c, 4c*).

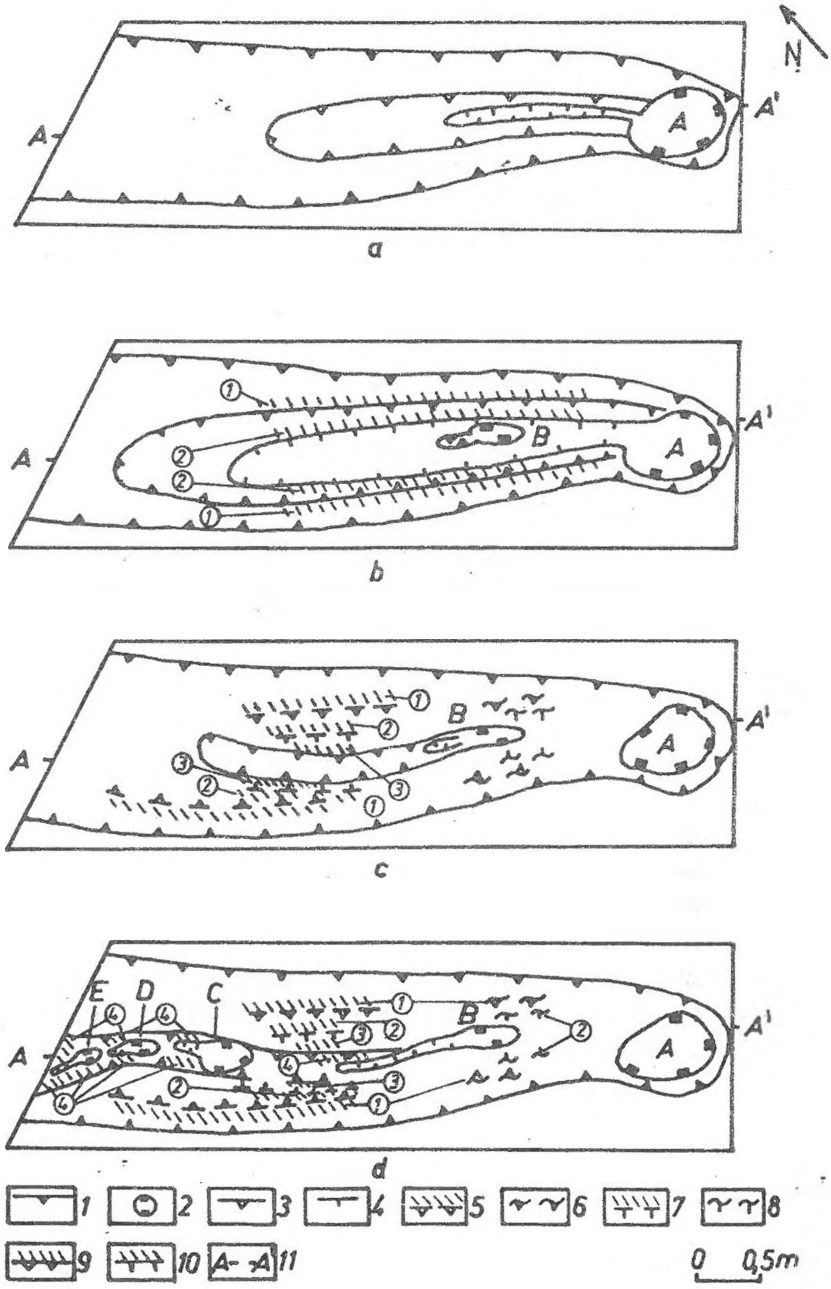


Fig 4: The history of the karren trough in plan
Legend: 1: rim of the major trough, 2: pit, 3: type II trough of pit B, 4: rims of type III troughs, 5: No. 1 terrace and residual terrace (remnant of the major trough bottom), 6: edge (remnant of No. 1 terrace), 7: No. 2 terrace and residual terrace (remnant of type II trough bottom of pit A), 8: edge (remnant of No. 2 terrace), 9: No. 3 terrace and residual terrace (remnant of type III trough bottom of pit A), 10: developing No. 4 terrace (remnant of type II trough bottom of pit B), 11: location of section

Following this during beheadings first pit C then further pits develop (D, E) in the type II trough of pit B. (The development of the No. 3 terrace probably stops because it gets no solvent or only a little after the development of the rest of the pits.) The type III troughs of the C, D, E pits develop (*Figures 3d, 4d*). The development of type III troughs means the development of a new No. 4 terrace from the bottom of the type II trough of pit B. This letter is not uniform even at the beginning because it is originated in the widening of four type III troughs that were separated by pits. Possibly the time of their development is different too: the type III trough at pit B is the oldest while it is the youngest in the type III trough at pit E.

It occurs that the development of terraces can be fitted without contradictions if the causes are explained by piracy.

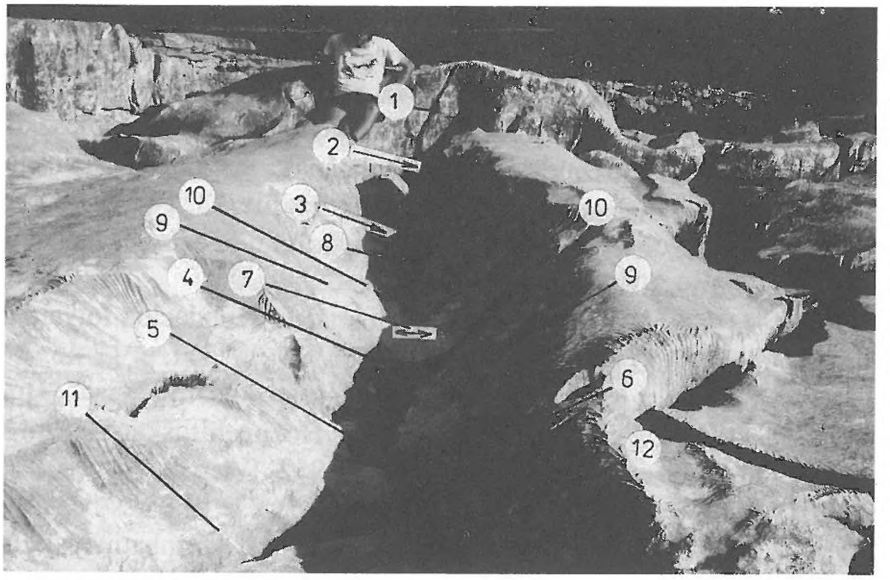
Resulted by the uniform (surface) solution of the side slopes the rims of the trough are rounded, the terraces are separated to remnants and then transform to edges. The dissolution of the trough sides is most considerable at the lower part of the trough. This may be connected with the fact that due to the slope of the sides the lower part of the trough receives more solvent than the rest of it.

It is expected that the laterally recharging solvent does not widen the trough significantly. This seems to be supported by the fact that the distance of the rims of the oldest terrace remnants and edges to the trough rims is nearly equal but the trough sides are more steep here than in the upper part of the trough. Here the dissolution of the trough sides appears as the digestion of the irregularities (terraces) and the lower part of the trough sides. The upper section of the trough is wider and the side slopes are less steep. Possibly here the upper part of the slopes is dissolved. This is hinted at by the better condition of the No. 1 terrace than it is in the lower section. (This is only possible if the bordering surface is dissolved in a greater degree than in the neighborhood of the lower section of the trough. This hints that the slope of the host ground surface is becoming ever less steep because of surface solution.)

Results

By the recognition of morphological properties and the explanation of their origin the history of development of a certain karren form can be sketched. It occurs that these forms in the case of karren troughs it is the terraces and pits.

- The position of the pits, their eventual discontinuity or missing the development by solution of the side slopes of the master trough can be deducted (slope retreating).



1.

Picture 1: Picture of the karren trough as seen from the north (vegetation at the Wiesenlacke Lake in the background)
Legend: 1: end of closed trough, 2: pit A, 3: pit B, 4: pit C, 5: pit D, 6: pit E, 7: type II trough of pit B, 8: type III trough of pit B, 9: No. 1 residual terrace, 10: No. 2 residual terrace, 11: the left hand tributary of the trough, 12: the right hand tributary of the trough

- The karren trough presented as an example developed as the result of a number of solution processes. The developing small- or part-forms generate new processes making the development of further forms possible.
- The development of a particular major trough is the result of self enhancing processes in case the initial conditions had been advantageous. The trough developing on a bedding plane terrain attract the solvent from its vicinity. Thus the development of other troughs stops or does not even commence, this resulting in the further development of the existing trough at an increasing pace.
- Two ways of the partition of bedding plane terrain is possible by troughs. It can be done by many troughs or by a single or several major troughs. In the letter case the developing trough extends its catchment area to an ever increasing area and an ever more complex development occurs in its interior.

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