*QUATERNARY STUDIES IN POLAND * 4 * 1983*

CRITERIA FOR THE DIFFERENTIATION OF LATE QUATERNARY RIVER TERRACES

WOLFGANG SCHIRMER

Department of Geology, University of Düsseldorf,
Federal Republic of Germany

ABSTRACT. In this paper the Holocene stratigraphy of the river Main (Bavaria) – one of the most detailed stratigraphies of the river Holocene – is worked up into a catalogue of criteria which offers characteristics suitable for the stratigraphic subdivision of Holocene river sediments in other valleys. As the best abstract for this criteria catalogue may serve Fig. 1 which combines the bulk of criteria in drawing and words. The evaluation of the criteria catalogue yields three essential breaks within the river development since the Würmian maximum: The first during the younger Würm Glacial after the Würmian maximum, the second and weaker one at the Würm/Holocene boundary – two climatic breaks – and the third one in the late Roman Period strongly influenced by man's clearance activity.

Introduction

Investigating the Würmian and Holocene river terraces of the valley ground the usual problem is: there are some exposures, some morphological or pedological facts. But for a complete construction of the valley ground they give only details and a small section out of the whole stratigraphical range of the valley fill. Therefore, identification criteria of a detailed subdivided key area would be helpful.

For the Central European Mittelgebirgs region at least such a key area has been elaborated in the upper course of the river Main in Franconia (Schirmer 1980a, 1981a).

In the following lines a catalogue of such criteria is drawn up which enabled to identify and to separate the different terraces and fluviatile sediments of the Main terrace sequence. For investigations in some river valleys of the Mittelgebirge a survey of those criteria proved to be very helpful.

Up to now this sequence consists of nine river terraces. Three of them belong to the Würmian Period and six to the Holocene Period (Fig. 1). All nine members are well-defined by their morphology, pedology, their interior structure with sedimentological and by their stratigraphical position. Up to now nowhere else a valley is known with such a complete and well-defined sequence of terraces. On the other hand, equivalents of some of these terraces can be found in other valleys (Becker & Schirmer 1977). It has been proved that they fit well into the terrace system of the river Main.

1. Morphological criteria

The terrace sequence of the river Main shows 4 terrace steps (Fig. 1): Low Terrace, Higher Floodplain Terrace, Middle Floodplain Ter-

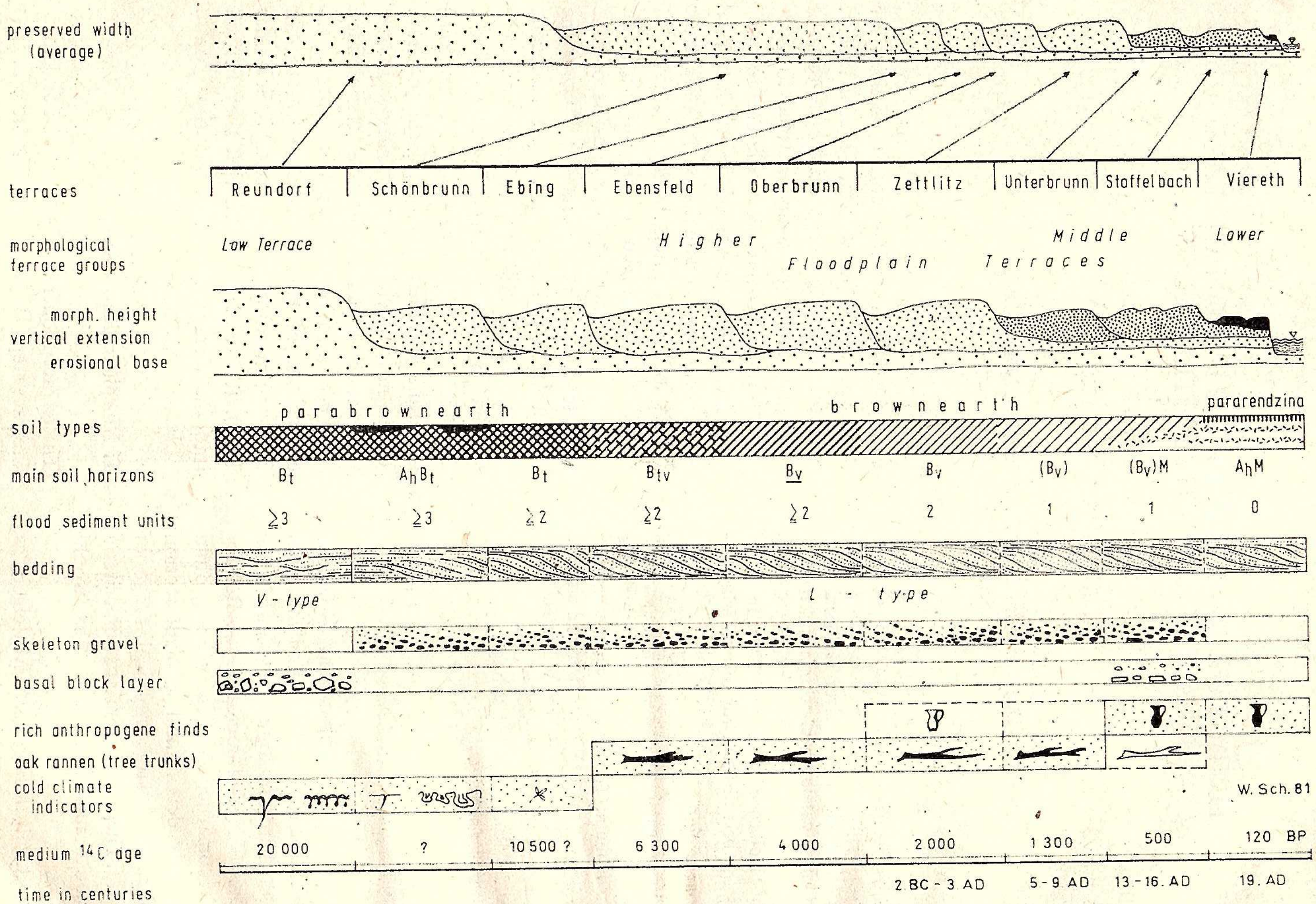

Fig. 1. Criteria for the differentiation of the Late Quaternary terraces of the river Main. The white areas within the last criteria bordered by little lines indicate findings outside the Main river catchment taken from other rivers of the Mittelgebirge

race and Lower Floodplain Terrace. Moreover the Higher Floodplain Terrace is subdivided by 5 terrace units which extend generally to the same height. The Middle Floodplain Terrace is subdivided by 2 terrace units. Morphologically as well as from the fabric of their sediment body the terrace units lie side by side so to say in row. Therefore they are called row terraces (Schirmer 1980a). Consequently a step terrace – as in the case of the Higher Floodplain Terrace – can include several row terraces.

The difficulty is to separate the row terraces. This is possible by a detailed subdivision of the floodplain morphology. Each row terrace has its own floodplain. A floodplain generally descends from the levee, flanking the river, across the valley floor down to the floodplain edge channel. Consequently the innermost part of the floodplain is the highest part, even if the terrace has been partly eroded (Fig. 1). In any case the outermost part is the lowest part of the floodplain. Where two row terraces contact each other there the lowest part of the younger one joins the highest preserved part of the older one. So they form a step though their average floodplain level reaches the same height.

A next difficulty is to identify the outermost channel of a floodplain, the floodplain edge channel, from the dense troop of floodplain channels which spread over a floodplain. Fig. 2 shows a troop of floodplain channels crossing the Staffelbach Terrace near Viereth. As one of many examples the map of Fig. 2 shows that a floodplain edge channel is formed by lining up to a thread the outer bows of the outermost meanders in a floodplain (compare the figure below with the figure above). Between single meanders bows characteristic corners are spread out which point towards the river.

Differentiating criteria also yield the shape of the floodplain edge channels: The Reundorf Terrace is delimited by an elongated nearly straight running floodplain edge channel. Since the formation of the Schönbrunn Terrace a meandering type prevails.

Moreover the troops of floodplain channels in the valley ground may give evidence for subdividing different floodplains. Such a channel troop runs almost parallel across the floodplain (Fig. 2). If a floodplain is composed of several row terraces, in good positions the younger troops cut the older ones unconformably marking a distinct cutting line. Such a cutting line is visible, e.g. in the south eastern part of Fig. 2 where the floodplain edge channel of the Viereth Terrace cuts the troop of internal floodplain channels of the Staffelbach Terrace. Such a morphological unconformity (Schirmer 1980a) can be a helpful indicator for separating row terraces especially in such cases when the morphology is uneven and crossed by a lot of channels.

2. Criteria given by the internal structure of a terrace

In the following the term terrace is used as a geological term for the whole fluviatile accumulation, including the terrace base, the sedimentary body, and ending with the terrace surface.

2.1. Horizontal extension of terraces

The horizontal extension of different terrace bodies differs considerably. Though the preserved parts of the terraces vary from section to section within the valley course a general trend can be stated.

The Reundorf Terrace, the Schönbrunn

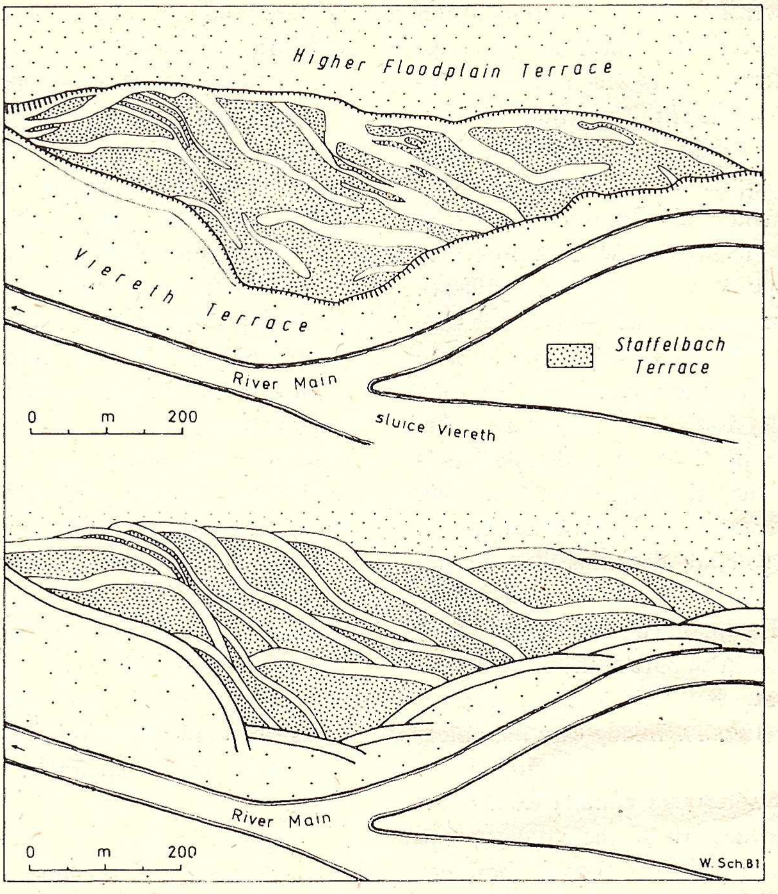

Fig. 2. above: Map of the Staffelbach Terrace with its floodplain channels northwest of Viereth. In a gravel pit within this area the channels prove to be relics of the gravel accretion structure. below: reconstruction of the gravel accretion within the Staffelbach Terrace marked by the preserved traces of main current lines

Terrace and the remaining group of the seven younger terraces cover three nearly equivalent parts of the valley ground (Fig. 1). The members of the group of the seven younger terraces are not fully equivalent. The Staffelbach Terrace for example is wider than the older ones considering the short time of its formation. The youngest one, the Viereth Terrace, is the smallest according to its very short time of formation. It runs nearly undisturbed as a small strip flanking the river.

2.2. Vertical extension of terraces

The vertical extension of the different terrace groups generally decreases from the older to the younger ones. The decrease is caused by a lowering of the terrace surface as well as an ascent of the terrace base. The decrease proceeds not gradually but in three steps (Fig. 1). The first step lies between the Reundorf Terrace and the Higher Floodplain Terrace, the second one between the Higher and the Middle Floodplain Terrace and the third one between the Middle and the Lower Floodplain Terrace. Each younger terrace is consequently a fill-in-fill terrace related to the older one.

Within two terrace groups – that are the Higher and the Middle Floodplain Terrace – the vertical extension of the row terraces is nearly the same, also the level of their surface/and bases.

Consequently below the Lower Floodplain Terrace three terrace socles of the older terrace groups are preserved, below the Middle Floodplain Terrace two terrace socles, and below any member of the Higher Floodplain Terrace only the Reundorf Terrace socle is preserved.

2.3. Types of bedding

Some terraces show differences not only by their arrangement but also by their integral structure. There are two types of bedding within the terrace gravel. The Reundorf Terrace prevailingly shows a flat bedding or a smooth trough bedding (Fig. 1) which is known from the braided river. It is a vertical aggradation type of gravel sedimentation (V-type after Schirmer 1981b).

In the younger terraces there occurs a largely dimensioned cross-bedding, that of the prevailingly meandering river. This bedding reveals a lateral accretion type of gravel sedimentation (L-type after Schirmer 1981b). In the Schönbrunn Terrace sometimes a very clear L-type of gravel bedding appears. Probably this terrace contains as a whole a mixed L-V-type. With the Late Würmian Ebing Terrace the L-type exists constantly till our days. But this means that the essential break between the river types does not lie at the change from the Würmian to the Holocene Period, but within the Würmian Period after the Würm maximum.

2.4. Facial indicators

Two facial indicators support this trait mentioned at last:

a. Firstly the basal facies: The V-type of gravel sedimentation shows at its base generally a lag facies as a residual bloc concentration. On the contrary the L-type of gravel sedimentation shows at its base a skeleton gravel (Schirmer 1978), a gravel with large pore volume and a lack of matrix. The latter especially enables to separate older terrace socles below the floodplain terraces.

b. Secondly the grain composition: Within its vertical section the V-type of gravel sedimentation shows a weak sorting, the L-type a clear vertical sorting and a matrix increase from below to above (Schirmer 1978, 1980a+b).

2.5. Flood sediment covers

The periodical gravel sedimentation of the floodplain terraces effected a periodical floodloam sedimentation. So in the floodplain there exists a number of flood sediment covers which are superimposed. Each cover ends with a soil the older ones of which are buried.

Generally the number of flood sediment covers increases from the younger to the older terraces. But on the top of the older terraces also the disturbances of the surface increase. So this criterion works only well with the younger terraces. Among them the number of flood sediment covers can indicate the age of the underlying terrace.

On the top of the Lower Floodplain Terrace there is no or merely a weak cover bed (Fig. 1). On the top of the Middle Floodplain Terrace there is one cover bed. The Zettlitz Terrace is covered by two flood sediment units and above the older terraces there are two or more cover beds.

The separation of different cover beds is possible by a fossil soil upon a buried flood sediment, sometimes by their different grain composition, more often by their soil chemistry data, e.g. phosphorus, iron, organic carbon (more details in Schirmer 1980a).

Conspicuous differences can also be registered in the thickness of the flood sediment covers. Maximum thickness occurs on the one hand with the Schönbrunn Terrace, due to the lack of vegetation, and occurs on the other hand with the cover belonging to the Staffelbach, Unterbrunn, and Zettlitz Terraces, due to the clearance activity. A small thickness can be stated in the case of the Ebensfeld and Oberbrunn Terrace as well as the young Viereth Terrace.

2.6. Soils

One of the best criteria to distinguish the terraces of the valley ground is their soil, developed on the top of the flood sediment unit covering conformably the underlying channel sediment. The older flood sediment is the more intensive is the weathering. The increasing range of the development of floodplain soils in the Main valley as well as in the whole Mittelgebrige region is (Fig. 1); Pararendsina (Viereth T.) – brownearth from a weak stage to a well-developed stage (Staffelbach to Oberbrunn T.) – transitional type between brownearth and parabrownearth (Ebensfeld T.) – parabrownearth (Ebing to Reundorf T.). Additionally on top of the Schönbrunn Terrace in deeper positions there lies a thick black humous soil (pseudo-chernosem) of Late Würmian age (Trieb soil, Schirmer 1977), later on transformed by the parabrownearth formation. This soil is a good indicator for the Schönbrunn Terrace.

These criteria fit only in the case where full terrestric soil development could take place. At places with semiterrestric soil development the differences hardly become visible.

The stages of soil development can also be demonstrated quantitatively, by their relationships of different iron contents (relation of the iron content involved into the soil forming process to the total iron content) (cf. Schirmer, Schnitzler 1980).

3. Criteria of relative and absolute dating

There is left the long catalogue of criteria for relative and absolute dating suitable to distinguish different Würmian and Holocene terraces which, however, is well known. The main points are listed here shortly (see also Fig. 1):

– sedimentary cold-climate indicators with ice-wedges, drop soils, cryoturbation

– plant fossils with rannen (tree tunks) and other wood remnants or pollen

– animal fossils, especially big mammals and molluscs

– anthropogene inheritances as implements, ceramics, pile constructions.

In this paper there is no place to discuss their suitability for the subdivision of Late Quaternary river terraces, but some features are exposed in Fig. 1. According to the floodplain clearance in a valley the end of rannen sedimentation, of course, can be later than in the case of the Main river. Likewise the onset of a rich content of ceramics in the river sediments can be earlier according to the cultural situation in a valley.

Such cases are marked in Fig. 1 with empty rannen and pots, surrounded with little lines.

4. Evaluation of the criteria catalogue

One single type of the criteria mentioned above is scarcely suitable to fit an unknown river sediment into the right stratigraphic position. But the combination of the criteria presented should give possibilities enough to identify the stratigraphic position of a river sediment at least approximately (cf. Fig. 1).

Several criteria yield breaks of different stratigraphical position. But there are striking breaks which are stressed by many criteria: One during the younger Würm Glacial between the Reundorf and Schönbrunn Terrace, a second one at the Würm/Holocene boundary between the Ebing and Ebensfeld Terrace and a third one in the late Roman Period between the Zettlitz and Unterbrunn Terrace.

The first incision is of pure climatic nature. It appears from the changing river type after the Würm maximum. At that time the river development already began which continues through the whole Holocene Period.

The second break is a clear change of the climate-indicating inventory of the valley due to the end of the Würm Glacial Period. But this climatic change influences the river activity less than the earlier one after the Würm maximum.

The third cut is again indicated by the changing of the river type. The reworking river in the valley is widening its radius of action. The erosional base therefore flattens. Generally this should be explained as a trend of cold climate environment. But in this case it has been strongly influenced – not completely caused – by man's impact on the floodplain. This new structure of the sedimental body is a reaction to the clearing activity which is weakening the erosion stability of the river banks, augmenting the floods and enlarging the freight.

There is no hint that in earlier periods of the Holocene man's activity could have influenced the river activity. The periodical reactivation of the meandering river has repeated itself since the fading Würm Glacial in such a similar way that there is no reason to doubt a climatic control.

MS. received 20 January 1982

Prof. Dr. W. Schirmer, Abt. Geologie der Universität, Universitätsstr, 1. D-4000 Düsseldorf, FRG

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