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Breaks within the Late Quaternary river development of Middle Europe

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ABSTRACT

Changes of climate and of man's behaviour caused some breaks in the river development which is characterized by 10 fluvial deposition phases (Fig. 1, 2). A Pleniglacial break (wu 1 / wu 2) with deep and/or lateral erosion is followed by the most important natural break (Wu 2 / wu 3) at the beginning of the Late Würm Period with change from braiding to meandering river and creation of the floodplains of our valleys. A slight break at the Würm/Holocene boundary is followed by changes of soil development: Start of brownification before and decease of parabrownearth after the Atlantic Period. Man's activity causes a most important anthropogenic break (hu 1 / hu 2) in the early Subatlantic Period with fill-in-fill structure of the fluvial sediments and silting up and levelling of the floodplain relief. The embankment of our rivers since the last century caused a last break. Lowering of groundwater level allowed the large access of settlement and agriculture into the floodplain.

Introduction

The development of our rivers and valleys since the maximum Würm Period has been controlled by climate as well as by man's impact on the valley regime.

After a twenty years investigation project of the Geological Department of the University of Düsseldorf in Middle Europe three river terraces of Upper Würmian age and seven terraces of Holocene age are known (Fig. 1). The main results refer to the rivers Main (Schirmer, 1980, 1981, 1983a,b, 1988a,b, 1991a), Danube (Schellmann, 1990a), Isar/Alpine foreland (Feldmann, 1990; Feldmann et al., 1991), Oberrhein (Schirmer & Striedter, 1985; Striedter, 1988), Niederrhein (Schirmer, 1990) and Weser (Schellmann, 1990b). All terraces are mapped over an area of some tenth of kilometers in different landscape zones of Middle Europe from the Alpine foreland down to the northern German lowlands. They all are well-defined as terrace bodies with base and top, with floodplain sediments and distinct floodplain soil types. Especially the latter allow to identify individual terraces. Moreover the age of the terraces and their simultaneity in different valleys is covered by a rich material of data, especially data gained from ^{14}C measuring, dendrochronology, pollen analysis and archaeology. The type area of the terrace sequence is the river Main with the most complete investigation and all terraces exposed from base to top.

The sequence of 10 river terraces forming the valley floor is not uniform at all. Distinct breaks of the hydrological regime led to a different picture of the single terraces or terrace groups. This individual style concerns the morphological feature as well as the pedological and geological interior of the terrace bodies. In the following the main breaks are lined out. Concerning the knowledge of the terrace sequences on the rivers Rhine, Main, Donau, Weser inclusive their tributaries see the detailed river studies quoted above. A stratigraphical view of them, united to one scheme, is outlined in Fig. 2. Respecting the regional investigations and results the following short text would be illegible if each statement would be accompanied by the quotations of all rivers and authors connected with. Authors and their investigated river areas are scheduled above.

1. Break Maxiwürm/Schönbrunn phases (wu 1 / wu 2 phases)

This break is an essential one. It took place during the course of the Upper Würmian Pleniglacial. It represents a big erosional phase, locally of more lateral and locally of more vertical erosion. The age of the break - due to lack of datings - can only be estimated between 19 000 and 17 000 (Fig. 2); for the Maxiwürm terrace can be connected with the maximum glacier advance in the Alpine foreland, and the Schönbrunn phase ends before the Bölling Interstadial. The erosional phase separates the vertical aggradations of the Maxiwürm (wu 1) and Schönbrunn terraces (wu 2).

On big rivers as the Niederrhein the Maxiwürm terrace has been removed almost completely. On middle-size rivers it has been preserved as marginal rims. On smaller rivers the wu 1 terrace maintains a good deal of the valley ground. On smaller streams of the Central Uplands as the river Main the erosion phases after the Maxiwürm terrace never reached its erosional base. Consequently the whole sequence of the following terraces is set into the wu 1 terrace with their base higher, their top lower than that of the Maxiwürm terrace (Fig. 3). All terraces following after this break are deposited as row terraces (base and top nearly at the same level). Quite other dynamics show the rivers Danube and Niederrhein (Fig. 3). On the Danube the Schönnbrunn terrace extends to the same erosional base than the Maxiwürm terrace. On the Niederrhein the wu 2 terrace cuts through the wu 1 base. May be, concerning the budget of the relation between water and freight, there was more freight and less water, during the Maxiwürm phase, less freight and more water during the Schönbrunn phase. So the stream erosion in the lower river course could balance better the lowered sea level than the river of the Maxiwürm phase.

2. Break Schönbrunn/Ebing phases (wu 2 / wu 3 phases)

Obviously it was the most important break in the river history since the last 25 000 years. It coincides with the change from Pleniglacial times to the Late Glacial times of the Würm. Climatic improvement with beginning spread of vegetation was the reason of the break. It started even before Bölling and ended with the passing of Alleröd (about 14 000-10 800 BP).

Change from braiding to meandering river, change from vertical aggradation to lateral accretion of river sedimentation, threshold of the important floodplain era in our valleys with deposition of fine-grained flood sediments which are the essential base for our agriculture in the valley floors, start of deposition of organic sediments (essential for ^{14}C dating and palynological dating possibilities), beginning of main floodplain soil development - these are only some outstanding changes marking this break.

In most valleys the Maxiwürm and Schönbrunn terraces lying before this break dominate the valley floor. The dimensions of the terraces after this break, the Ebing and following terraces, are much smaller due to a reduced supply of freight.

3. Break Ebing/Lichtenfels phases (wu 3 / hl phases)

This break coincides with the Würm/Holocene boundary. The climatic improvement on this turning-point only promotes some effects which results from the latter break: Terrace dimensions lessen again. The supply of fresh freight from the catchment area closes nearly completely. Mere redeposition of sediment prevails. With the end of cold climate processes the forming of ice wedges, drop soils and cryoturbations in the river sediments ceases. Deposition of organic material increases.

With the Lichtenfels phase the age of rannen (buried tree trunks) within channel sediments starts, at first with fir rannen, soon after with oak rannen. The rannen give evidence of a wooded floodplain and are, of course, essential for dendrochronological dating.

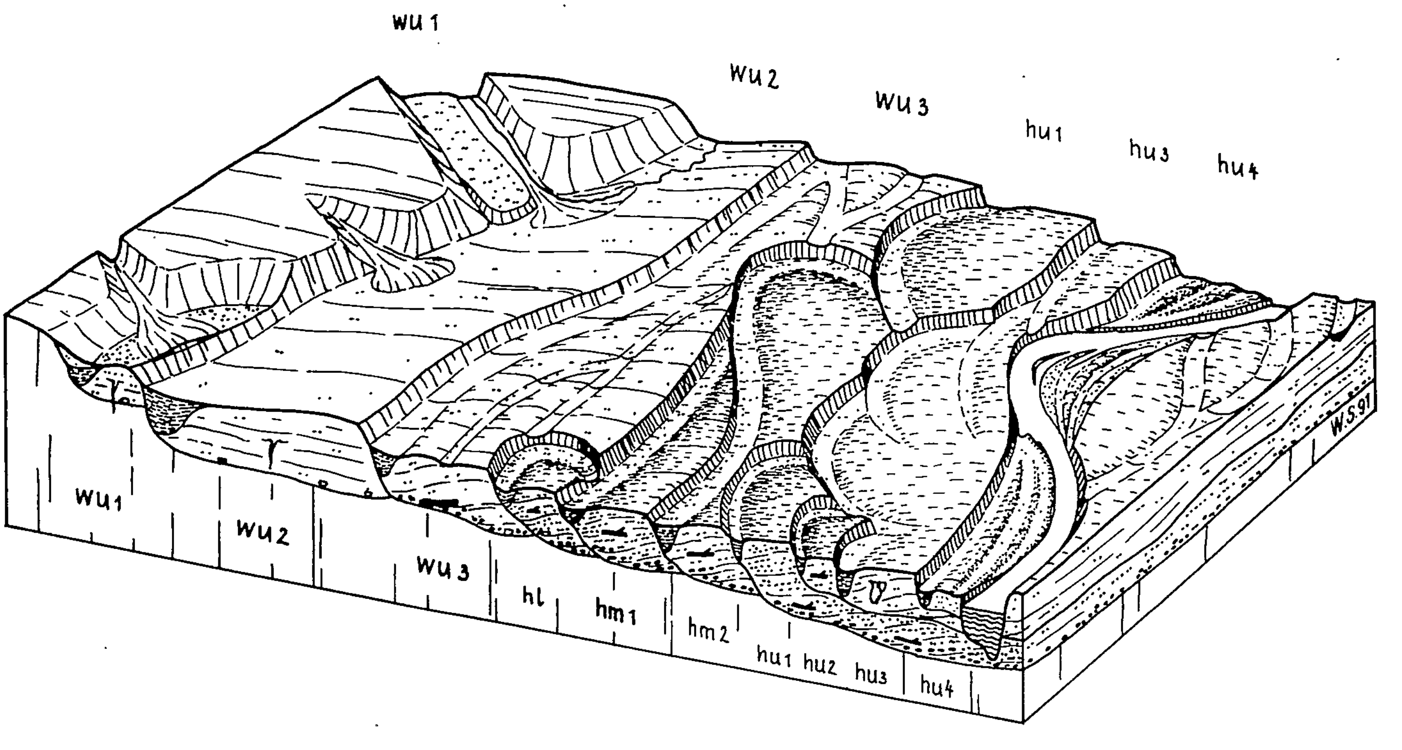

Fig. 1. *Scheme of the structure and stratigraphy of the valleyground in Middle Europe. wu = Upper Würm, hl = Lower Holocene, hm = Middle Holocene, hu = Upper Holocene.*

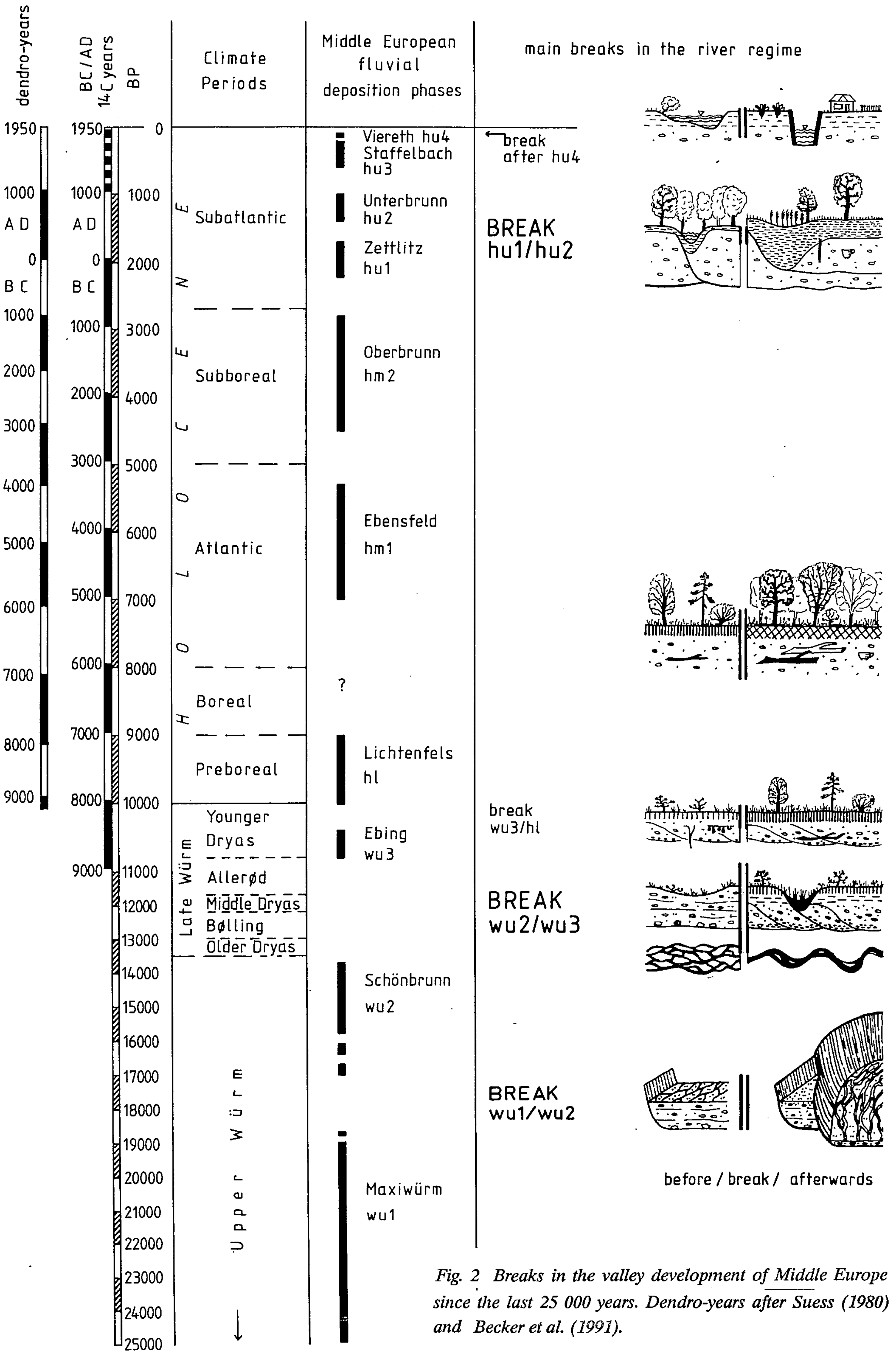

Fig. 2 Breaks in the valley development of Middle Europe since the last 25 000 years. Dendro-years after Suess (1980) and Becker et al. (1991).

The redeposition of river sediments from the Lichtenfels phase on is only controlled by phases of increased flood periods which cause the following redeposition phases. The gaps between the phases are not completely free of floods. Therefore enough rannen have been produced to build up an oak rannen chronology covering nearly the whole Holocene (Becker, 1991, 9). But the gaps between the redeposition phases, respectively the concentration of floods to distinct redeposition phases are modelled well enough to create distinct large river sediment bodies lying in the floodplain as step or row terraces. (Step terraces have the terrace top and/or base lower than that of the preceding one. Row terraces (Schirmer, 1980, 13) are lying side by side with the terrace base and top nearly at the same level.)

4. Break Zettlitz/Unterbrunn phases (hu 1 / hu 2 phases)

This break again is an essential one. The Holocene terraces up to the Zettlitz phase form row terraces, sometimes with a tendency to step terraces. From the Zettlitz phase on, however, they tend to be set into the older ones (fill-in-fill structure). The rise of the channel base is counterbalanced by a widening of the channel.
Moreover, flood sediment deposition is increasing from this break on, and together fluvisoliment (redeposited soil material) augments up to the recent times. With the extention of floodplain sediments the older floodplain relief starts to be filled up to become more and more even.
All this is due to slope and valley clearance. Deforestation of the floodplain destabilizes the river banks and causes the channel widening and shallowing. Soil erosion on slopes and in the floodplain augments flood sediment as well as fluvisoliment. Human refuse and inheritances designate the fluvial sediments more and more. Bones of wild animals give way to bones of domestic animals.

This break is only man-caused. Man's input into the valley budget, however, is obviously older than this break. An augmentation of floodplain sediment, for example, is visible in some valley reaches since the Neolithic settlement. But to become efficient for an alteration of the river regime it needs an accumulation effect to gain a distinct treshold for a change. And this change had its climax after the Zettlitz phase.

To avoid misunderstandings both redepositions phases, the Zettlitz and the Unterbrunn phase are of climatic origin. They coincide, by the way, with glacier advance phases (Schirmer, 1988b, 34). Only the different style of both phases is what makes the break. Only the different style of both phases is what makes the break. And that is what is man-caused.

5. Break after Viereth phase (hu 4 phase)

This break is the transition from the river to a canal. It happens, of course, not on all rivers and not at the same time. Canalization means narrowing and stabilizing the river banks. Rivers react, above all, with incision. The effect of canalization is predominantly lowering of the groundwater table, decrease of freight transport and consequently decrease of sedimentation. The life of river has been restricted.

Thus this break is a certain end of the river development - concerning the canalized river itself. But also the catchment area becomes involved into this process. Tributaries have to follow the incision. This causes an increase of river activity in the catchment area, increase of bank cutting, meandering, freight redeposition and gives rise to landslides and debris flows promoted by advanced clearing of the landscape.

In this way this break is revolutionizing the whole landscape. In Middle Europe its climax runs about 1850 AD.

6. Breaks in soil development

During the Holocene, beside the development of different varieties of soil types for each terrace, distinct breaks in the soil development can be registered.
1. Turn from A-C soil types to A-B-C soil types before the Ebensfeld phase (hm 1).
2. Cease of parabrownearth development after the Ebens-

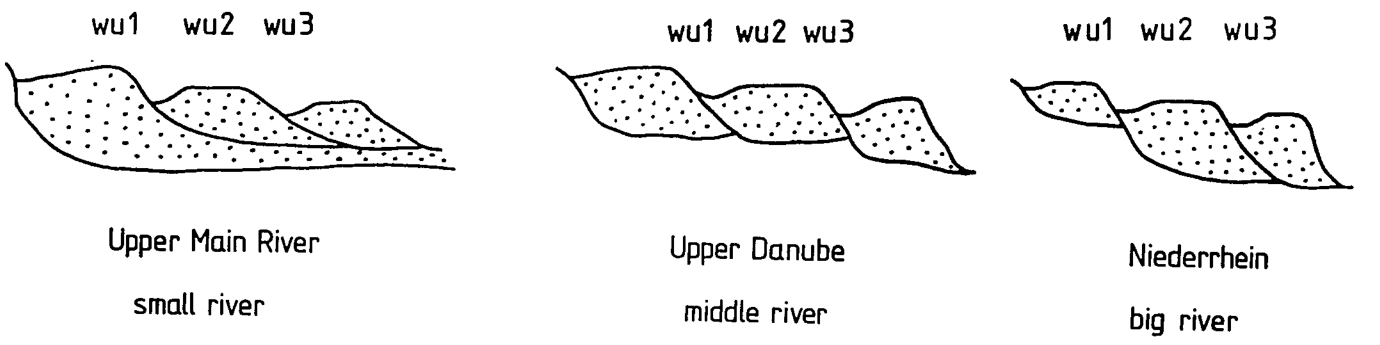

Fig. 3. *Scheme of the architecture of the Würmian terraces in Middle Europe (after Schirmer, 1991b).*

feld phase (hm 1).
Whether these breaks are under hydrological control or not is not sure.

ad 1. The first turn from A-C soils to A-B-C soils happens between the Lichtenfels and the Ebensfeld phase (hl / hm 1 phases). It is a turn from pseudo-chernozem soil types to parabrownearth. Whether the soil types turn at this break or later or never depends on the lime content of the substratum of the respective valley reach. The higher the lime content the later the outset of the brownification (Schirmer, 1988a, 159). The time fixation of the beginning of brownification is not easy. The brownification of the Ebensfeld terrace could start right after the deposition of the covering flood sediment. As the deposition of the whole terrace sediment is a lateral one the brownification could have started with the early lateral accretion of the Atlantic sediments. From loess plateaus in Middle Europe the change from chernozem to parabrownearth is known turning up before or with the Neolithic settlement (the latter at about 7000 BP) (Schalich, 1973, 4; Schirmer, 1991a, 158).

ad 2. After the Ebensfeld phase (hm 1) the forming of parabrownearth as floodplain soil type ceases in favour of brownearth - perhaps due to increased supply of unweathered sediment during flood periods produced by human clearance activity in the valley catchment.

Conclusions

A first question to this sequence of breaks is their importance for the glacial-interglacial behaviour of the river. The main erosional phase was the break Maxiwürm/Schönbrunn phase. In the Rhine system and Central Uplands the most important lateral and vertical erosion took place during this break. On the Alpine foreland rivers the down cutting proceeded gradually from the Maxiwürm/Schönbrunn break up to the Zettlitz phase (hu 1), and on the Alpine foreland Danube from the Schönbrunn/Ebing break up to the Zettlitz phase.

This means for the Central Uplands that the main erosion from glacial to interglacial happened already within the glacial period, but in its later phase. The same was concluded from the Middle Pleistocene terraces of the Lower Rhine (Schirmer, 1969).

Looking on the Alpine foreland it results that the down cutting extended from the later Pleniglacial up to the Holocene. This difference is due to the glacier and snow controlled water budget and the different relationship of water and freight between the Alpine and the Central Upland rivers.

In the Alpine foreland a slower retreat of freight caused a gradual incision. In the Central Uplands, the periglacial area, a sudden retreat of freight after the glacial maximum results in a distinct erosional phase. On the Rhine the lowered sea level during the glacial period promotes an additional down cutting.

A second question to this sequence of breaks is their importance for our present landscape.

The most important break, of course, was the Schönbrunn/Ebing break, that of the revival of the vegetation with stabilization of soils, end of the bulk of soil erosion, start of the meandering river and together with it the origin of a floodplain in our valleys. It was a break of climatic improvement.

The next important break, however, was the anthropogenic Zettlitz/Unterbrunn break. It documents in the best way the change from the wooded floodplain to the cultivated floodplain which at present bears fields, meadows and settlements. Agriculture was promoted by the enormous augmentation of flood sediment, levelling of the floodplain relief and covering the mires of the floodplain channels and back swamps. In addition the last break, that of the last century, promoted by its lowering of the groundwater table the large scale access to the floodplains for settlement and fields where meadows have been before.

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