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Holocene valley development on the Upper Rhine and Main

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ABSTRACT: The results on the Upper Rhine presented here, compared to those on other Central European Rivers, give certainty that the reworking phases of the River Main cannot be of local nature. There is a major control - the Holocene climate with its fluctuations - effecting the rhythmics of reworking phases in the river valleys.

1 AIMS

On the Main River a detailed sequence of Late Glacial and Holocene reworking phases of the river has been worked out (Fig. 1, and SCHIRMER 1983b). The question was, whether this sequence of reworking phases would be local - caused by climatic events and human impact on the valley - or would indicate an influence of widespread climatic control. The latter has been concluded from the following facts: (1) The terraces of the Late Glacial Period have undoubtedly been effected by distinct and well-known climatic changes, as for example the Younger Dryas Period. (2) Style and structure of the Holocene terrace range continue exactly those of the Late Glacial Period. (3) Man's impact becomes evident by quite other features, e.g. flattening of the river channel bottom combined with a tendency towards braiding - as it is the case in the Unterbrunn and Staffelbach Terrace along the River Main. Further traces of man's influence are:

- augmentation of flood sediment
- input of preweathered soil material into the valley floor by soil erosion processes in the catchment area of the river
- increase of carbon content in the floodplain sediments
- change of the floodplain vegetation by clearance activities in and outside the valley floor. This effects a change of the wood spectra, preserved within the terrace gravel, as well as a change of the pollen spectra of the flood sediments
- increase of anthropogene finds in the channel sediment. (4) On the rivers in Middle Europe a terrace sequence comparable with that of the River Main did not exist up to now. But there exists a lot of local studies (reviewed in SCHIRMER 1973, 1974) and, moreover, own local unpublished studies along the rivers Saar, Mosel, Erft, Lahn, Sieg, Ruhr and Lippe (all belonging to the Rhine catchment area), which all fit well into the system of reworking phases of the River Main.

Nevertheless further and more detailed evidences are necessary to give the proof that climate would have caused different rivers to rework the valley sediments simultaneously and rhythmically. Thus, the following investigation of the Upper Rhine area north of Strassburg (Strasbourg) may give an example to serve this aim.

2 HOLOCENE VALLEY DEVELOPMENT ON THE RIVER RHINE NORTH OF STRASBOURG (STRASSBURG)

2.1 Landscape zonation

In the Alsace 25 km north of Strasbourg, the westward valley plain of the Rhine River represents an inner part of the Upper Rhine Graben. There, a cross section of the valley surface shows a distinct morphological zonation of the floodplain landscape. This morphological zonation is

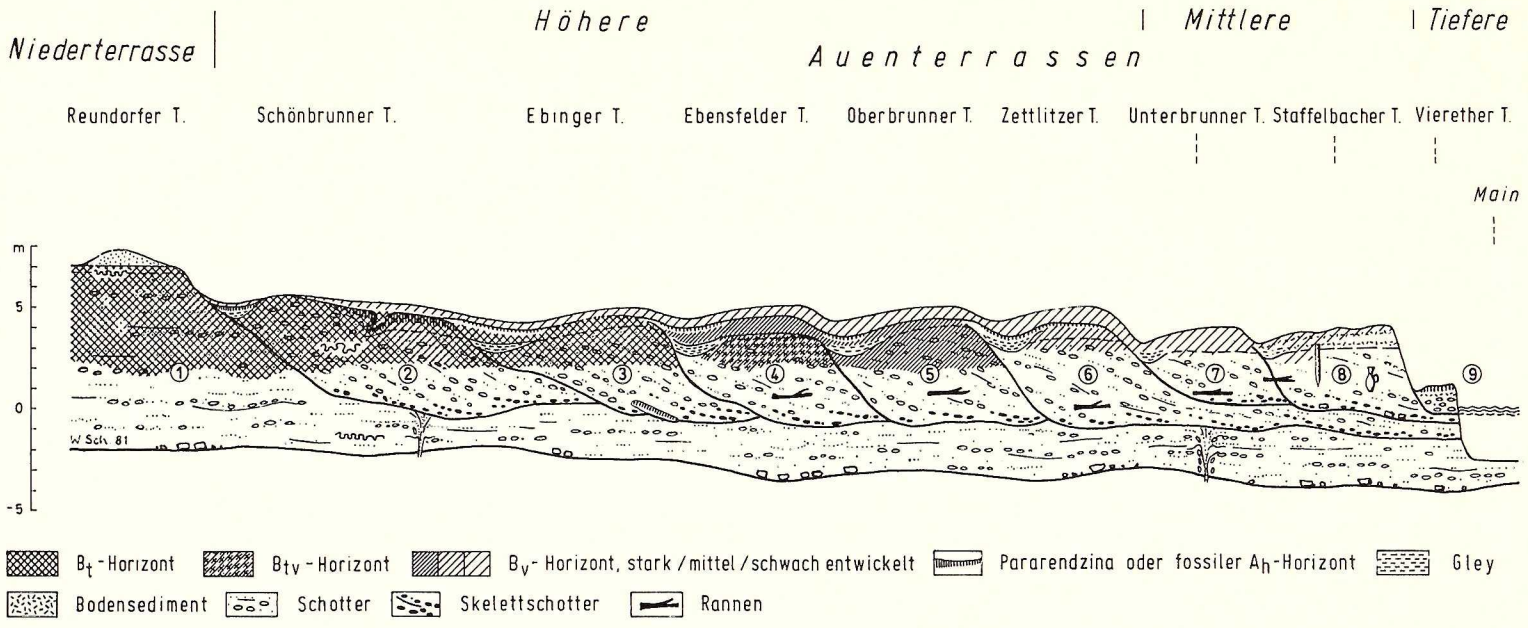

Figure 1. Scheme of the Würm and Holocene valley fill of the upper Main and Regnitz Rivers (from SCHIRMER 1981). 1 - Würm Pleniglacial, 2 - post-Pleniglacial, pre-Alleröd, 3 - Younger Dryas, 4 - Atlantic: 5850-4300 BC, or 7000-5400 y BP^{+}, 5 - Subboreal: 3250-1750 BC, or 4500-3500 y BP^{+}, 6 - Subatlantic: 200 BC - 250 AD, 7 - 550-850 AD, (4-7 = dendro ages; $^{+}$ = ^{14}C age), 8 - 15th - 17th century, 9 - early 19th century.

accompanied by typical field names underlining the character of the morphological zones as ecological zones (SCHIRMER 1985).

The Rhine is bordered immediately by the Auwald Zone (Riverine Forest Zone). Nowadays this zone is almost completely wooded and diked.

To the west follows the Wörth Zone ("Wörth" means an island within a river). This landscape is occupied by agricultural fields, and more rarely, by meadows. It was flooded by all major floods of the Rhine up to some decades ago. Well preserved large meander bows of relatively young age mark this zone (e.g. in the area of Sandwörth, Altwörth and Neuwörth near Offendorf and in Mühlwörth near Gambsheim; see Fig. 2).

Towards the valley edge there follows the Felder Zone (Field Zone). It takes the highest position within this side of the Rhine valley floor (e.g. Bühlfeld, Stockfeld and Neufeld around Gambsheim and Offendorf). Old settlements of the valley floor followed this zone - which can be derived from the ending -heim of the place names - as did the lines of the old main roads and of the railway forming the Alsatian north-south connection. A well developed morphological subdivision of this zone does not, however, deny its homogeneous general character. To the west there follows the Matten Zone (Meadow Zone). This plain, smoothly descending towards the valley edge, was formerly a pure meadow landscape, as suggested by the field names "Hutmatt", "Riedmatten", "Katzenmättel" and "Bodenmatt" situated between Gambsheim and Herrlisheim. But nowadays it is used as arable land. There also occur small areas of forests, and in wet depressions reed vegetation. This zone represents a morphological transition from the Felder Zone to the Ried Zone. The outmost part of the valley floor of the River Rhine is formed by the Ried Zone (Reed Zone). This zone borders the Tertiary hill country which is higher in elevation.

2.2 Geological zonation

Geological and pedological investigations made by SCHIRMER and later on by SCHIRMER & STRIEDTER (1985) revealed these landscape zones to be a result of a fluctuating river history. Each zone represents a particular sedimentation period or several sedimentation periods; the boundaries of the landscape zones are also sedimentary unit boundaries.

Auwald Zone

The early topographical map of TULLA (1938) shows this zone lying eastward of Offendorf completely in the area of the branching network of the Rhine as present before river correction.

Thus, TULLA's map shows the Auwald Zone being an area of active fluvial working in the early 19th century. The gravel of this zone contains young cultural finds, e.g. near Fort Louis (GEISSERT et al. 1976), situated down the river in map Fig. 2. At locality 1 in Fig. 2 rannen (fossil tree trunks) occur with preserved cutting traces at the base of the trunk.

In the gravel pit Offendorf-"Fahrkopf" (locality 1) a 2 m section above the groundwater-table is exposed. Above the 19th century gravel there follows 60 cm of fine sandy flood sediment (Fig. 3). On top of it, a 10 cm thick calcareous pararendzina has been developed. The lime content of the C horizon is 19-23 %. In the A horizon it diminishes from the base to the top to 14 % - evidence of weak decalcification of the pararendzina.

Wörth Zone

The floodplain terrace of the Wörth Zone is 1-2 m higher in elevation than the Auwald level. Its surface has an undulating fresh morphology. A fair number of large meander bows has been well preserved, and are now partly filled with groundwater. The gravel of the pit Gambsheim-"Kälbergrün" contained a millstone, and that of the gravel pit Offendorf-"Sandwörth" ceramics as well as rannen with preserved cutting traces.

The cultural finds date the gravel from the High Middle Ages on.

There is a distinct hiatus evident between the Wörth Zone and the Auwald-Zone, consequently the Wörth Zone gravel has to be assigned to the older part of the time span.

The gravel is covered by a 0.5-1 m thick fine sandy floodplain sediment. Its soil profile exhibits a 25 cm thick calcareous humus at its top, followed below by a B horizon of 20-25 cm thickness, weakly brown and slightly decalcified (B horizon 12 % $CaCO_3$; C horizon 18 % $CaCO_3$). The soil type is a braunified pararendzina.

A great number of older rannen lies in deeper gravel beds below that of the Wörth Terrace, as well as below gravels of the Auwald Terrace. They give evidence that both gravels, Wörth and Auwald, are superposed over different gravels of older Holocene age.

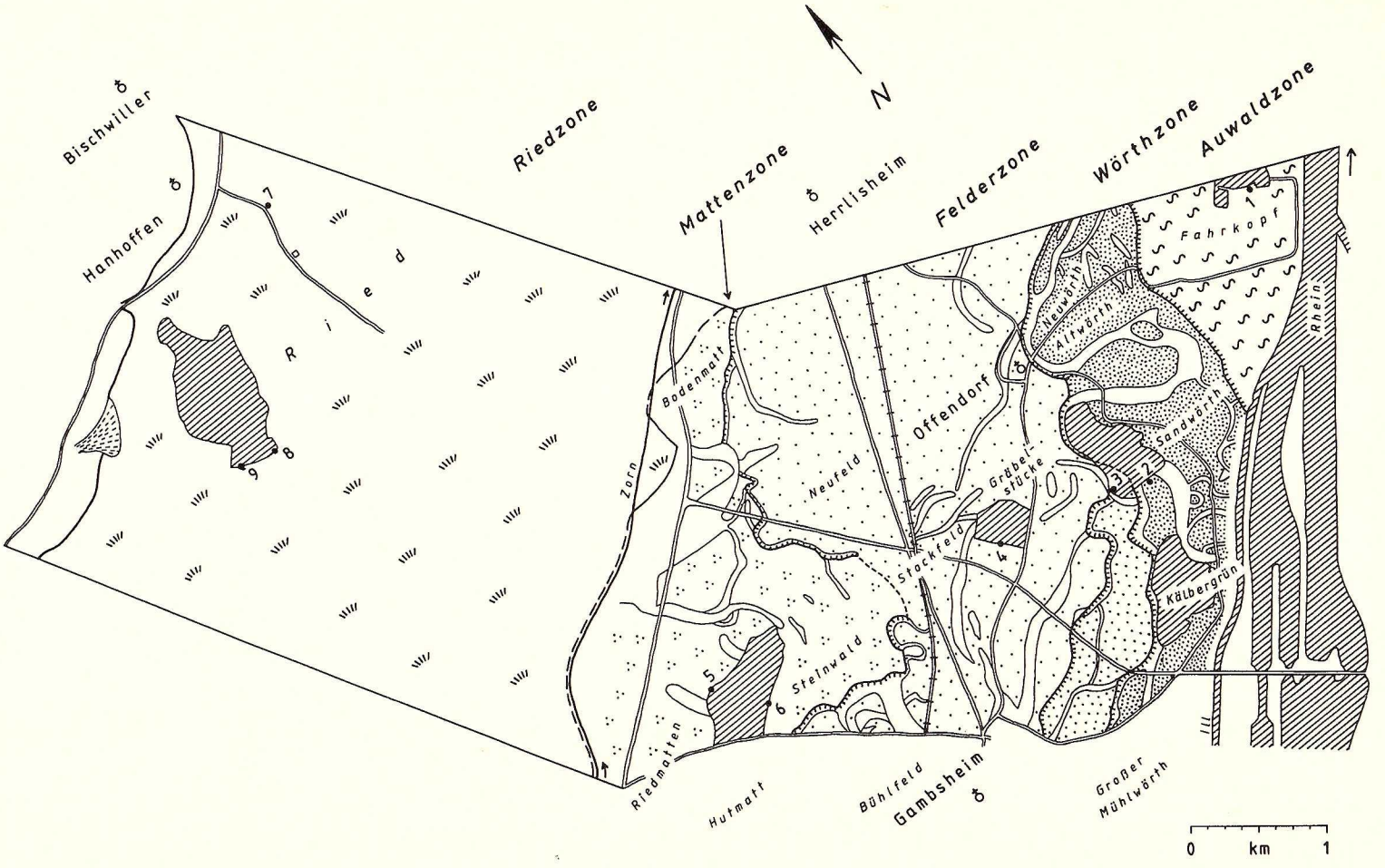

Figure 2. Terrace sequence of the Rhine plain 25 km north of Strasbourg (Strassburg), from SCHIRMER & STRIEDTER 1985.

Felder Zone

Fig. 2 shows this zone subdivided into two distinct terraces. Farer to the north K. STRIEDTER (in preparation) could meanwhile subdivide this zone into three terraces.

Lower Terrace of the Felder Zone
(Densly dotted small area in Fig. 2)

Their mean elevations lie about 0.5 m above the Wörth Zone surface. The gravel dates to the Early Middle Ages or older. The former date is indicated by the trunk of a ranne with the final tree ring year 589 AD, excavated in this terrace area in the gravel pit Offendorf-"Sandwörth". Rannen of this age occur frequently in this region (BECKER 1982:45).

At locality no. 3, in the upper terrace section the gravel is overlain by a fine sandy floodloam sediment up to 1.4 m thick. Below the humus horizon (30 cm thick) a distinct B_V horizon of 35 cm thickness has developed. The A horizon is rather decalcified (A horizon: 5 %, B: 14 %, C: 19 %). Soil type: pararendzina-brownearth.

Higher Terrace of the Felder Zone
(Widely dotted large area in Fig. 2)

This highest part of the floodplain landscape in the Rhine plain rises up to 1 m higher than the Lower Terrace of the Felder Zone. Under the groundwater-table of the gravel pit Gambsheim-"Gräbelstücke" there occur three rannen layers (R 1-3) dating to the middle and late Subboreal (^{14}C dating by M. GEYH, Hannover).

R1 8 m bel. surf. 3030±55 y BP (Hv-13 118)
R2 12 m bel. surf.
R3 17 m bel. surf. 3600±55 y BP (Hv-13 117)

Above the gravel of this terrace body the fine sandy floodloam of 60 cm thickness is completely decalcified and altered to a brownearth; the weathering also affects the upper parts of the underlying gravel (see Fig. 3).

Matten Zone

Towards the valley edge the surface of this zone gradually descends down to 1 m below the Felder Zone. Two ^{14}C dates of oak rannen date the gravel of the pit Gambsheim-"Steinwald" to the middle up to the late Atlantic period.

top of the gravel 4430±65 y BP (Hv-13 114)
deeper part of the gravel below the water level 5810±70 y BP (Hv-13 116)

The former soil on the fine sandy-silty flood sediment was a black pseudo-chernozem which, however, later on has been transformed to a parabrownearth. Both soils are now completely decalcified.

Ried Zone

Descending to the valley edge down to 1-3 m below the Matten Zone, the Ried Zone occupies the deepest position within the valley cross section. No wonder that the groundwater-table lies near the surface and the floodplain is overgrown with reeds. The upper parts of the gravel in the pit Hanhoffen are free of finds. This hints at a pre-Holocene age of the gravel. As for its deep position in the valley it should be of Late Würmian age. This age is confirmed by a pollen diagram from peaty parts of the Ried analysed by HATT (1937:70) the base of which indicates a Late Würm age.

On higher positions of that zone, on top of a 90 cm thick silty-fine sandy flood loam, a stony parabrownearth was developed. Later on, it was buried by a 70 cm thick fine sandy flood loam that includes ceramic finds. The surface of this loam is marked by a brownearth soil profile.

Deeper positions of that zone - the typical reed landscape - are completely gleyed. All such sections expose the surface soil as a wet-gley (Nassgley) or a gleyed brownearth, followed below by a second, buried, wet-gley. Pollen analyses (U. ERTL, Düsseldorf) date this buried soil containing Fagus, Secale and Plantago lanceolata to be subboreal or younger.

The geological map (scale 1:25'000, sheet Brumath-Drusenheim) of this region (MAIRE et al. 1972) shows the Holocene terraces and gravel bodies of the Matten Zone, Felder Zone and even part of the Wörth Zone as an area of Würmian gravel aggradation. The small seam along the Rhine River left in the map as Holocene sand and gravel alluvium actually corresponds to only the youngest Holocene, from the Late Middle Ages on.

While the Rhine plain has formerly been interpreted as a result mainly of Würmian sedimentation, the investigations of SCHIRMER & STRIEDTER (1985) give evidence that the plain is the result both of Late Würmian sedimentation and, to a large degree, periodically gravel reworking in the Holocene.

Meanwhile K. STRIEDTER is continuing this study upstream and downstream of our research area - an investigation for taking his doctor's degree. He added to

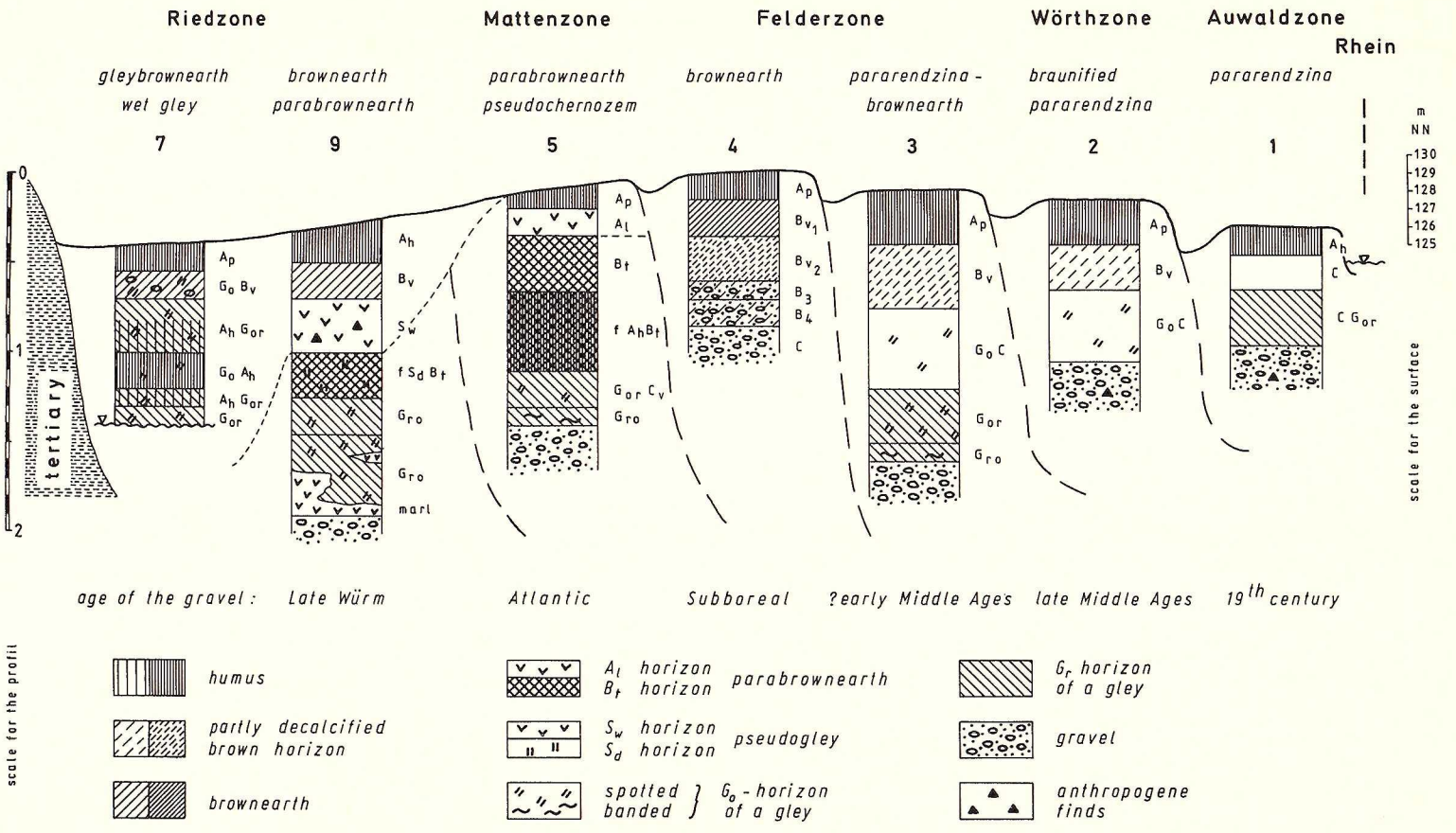

Figure 3. Cross section through the Upper Rhine plain north of Strasbourg (Strassburg), from SCHIRMER & STRIEDTER 1985.

the two terraces of the Felder Zone a third one, thus, subdividing the Felder Zone into a Higher (Subboreal), Middle (Roman Period) and a Lower one (Early Middle Ages) (K. STRIEDTER, in preparation).

3 MAIN AND UPPER RHINE

These preliminary results from the Alsatian Upper Rhine give evidence that the Holocene river history in the Upper Rhine Graben (with its tectonic subsidence) included also periodic events of sedimentary activity, as it is known from other regions such as the Alpine foreland, the Central uplands and the Northern German lowlands, and, in great detail, from the River Main (SCHIRMER 1983).

As on the River Main, the Holocene reworking phases of the Upper Rhine are represented as row terraces (SCHIRMER 1980:13, 1983a:201, 1983b:28). Likewise these row terraces can be well separated by morphological and pedological criteria (cf. SCHIRMER 1983a,b).

Up to now the dating of the individual terrace bodies on the Upper Rhine has not been accomplished in a similar level of detail as on the River Main. Therefore a stratigraphic correlation of both rivers can only be done roughly. However, all six Holocene terraces known from the Alsace so far have, according to their first datings, good equivalents in the Holocene terrace sequence of the River Main (compare Fig. 1, 3).

Moreover, the soil development also exhibits similarities. As the lime content of the unweathered substratum is much higher on the Upper Rhine (about 20 %) than on the River Main (about 0.5 %), the soil development is not identical. However, there is evidence of a predominance of black floodplain soils of the pseudo-chernozem type in the Late Würm and older Holocene - on the Upper Rhine up to the late Atlantic Period, on the River Main only to the Preboreal. It is followed or replaced by the development of a para-brownearth - in both valleys upon the flood sediment of the Atlantic gravel at the latest. The terraces from the Subboreal on exhibit soils of the developmental range pararendzina to brownearth, from the youngest to the older terrace, with a gradual intensification of development (see Fig. 3). This soil development, of course, proceeds much more quickly in the Main terrace sequence with its low lime content than in the Upper Rhine terrace sequence with its higher lime content. Thus, the Main sequence exhibits the brownearth stage in external parts of the Staffelbach Terrace (SCHIRMER 1983b:24), which correspond approximately to the Wörth Terrace of the Upper Rhine. In contrast, the Wörth Terrace only exhibits the incipient development of brownification.

Despite the influence of parent material composition, it is nevertheless clear that time is the dominant control on soil profile development from the Würmian Period on up to today. This enables to date floodplain terraces by their soil - provided that the soil catena has been adjusted to the age of the respective terraces at a proper place.

A further attempt to prove this stratigraphical system of reworking phases are the investigations on the Lower Isar River and adjacent Danube River made by G. SCHELLMANN (in preparation) on the base of former investigations by BRUNNACKER (1959) and HOFMANN (1973). There is a quite similar range of floodplain terraces, coinciding stratigraphically with that of the River Main. There is also a well-differentiated soil catena in which each soil type marks a distinct floodplain terrace. Due to a lime content of the floodplain sediments, much higher than that on the Upper Rhine, the Holocene soil catena moves within the range para-rendzina to pseudo-chernozem.

The first results on the Upper Rhine presented here, together with those on other Central European rivers, give certainty that the reworking phases of the River Main cannot be of local nature. There is a major control - the Holocene climate with its fluctuations - effecting the rhythmics of reworking phases in the river valleys. Consequently, the reworking phases of the River Main cannot be restricted to Middle Europe. They should occur much more spread out, modified locally by climatic features of an individual region, and, in the younger Holocene Period, modified by man's activity of that region.

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