ARAGUAIA 99

INTERNATIONAL SYMPOSIUM ON GEOMORPHOLOGY AND PALEOHYDROLOGY OF LARGE RIVERS

GLOCOPH-IAG

BOLETIM GOIANO de Geografia

special issue
vol. 19(1): 1999

FEDERAL UNIVERSITY OF GOIÁS
INSTITUTE OF SOCIAL & ENVIRONMENTAL STUDIES - IESA

Editora UFG

Heine K. / B. Goiano de Geog. v. 19 (1): 82-93 (1999)

FLUVIAL RESPONSE OF THE DANUBE RIVER TO CLIMATE CHANGE IN BAVARIA DURING THE WEICHSELIAN AND THE HOLOCENE

Klaus Heine

Regensburg / Germany

Fluvial style changes of the Danube River were studied from the Middle Pleniglacial(oxygen isotope stage 3) until recent times by a working group in the Deparment of Physical Geography at the University of Regensburg. Areas of investigation were the valley of the Danube River in the Regensburg area, the Altmühl valley and the tributary river system (Fig.1). Furthermore, in recent years the investigation were extended to the surroundings of the great valleys covering the western parts of the Tertiary hills south of the Danube and the Mesozoic limestone areas northwest of the Danube. By linking the paleoenvironmental changes documented in fluvial and colluvial as well as (paleo) soil sequences we can demonstrate that the fluvial development is rather determined by autocyclic erosion/accumulation rhythms than by the climatic rhythm.

According to our present knowledge, the fluvial geomorphodynamics are described best by the *dynamic process-response model of river channel development* by Hey (1979). The formation of flood plain terraces (in the geological and geomorphological sense) during the Holocene was mainly influenced by the fluvial development during and since the Pleniglacial of the last glaciation (Heine, in press). Diferent sections of the valleys of the Danube and Altmühl Rivers document different geomorphodynamic responses of the rivers to external climatic impacts. Repeated phases of incision and deposition, whereby the rivers became confined to an increasingly narrower flood plain, resulted in the forming of three levels of the Low Terrace and three (or four) levels in

the Flood Plain Terrace (Buch 1988a ;Buch & Heine 1995; Hilgart 1995; Peterhoff 1986)

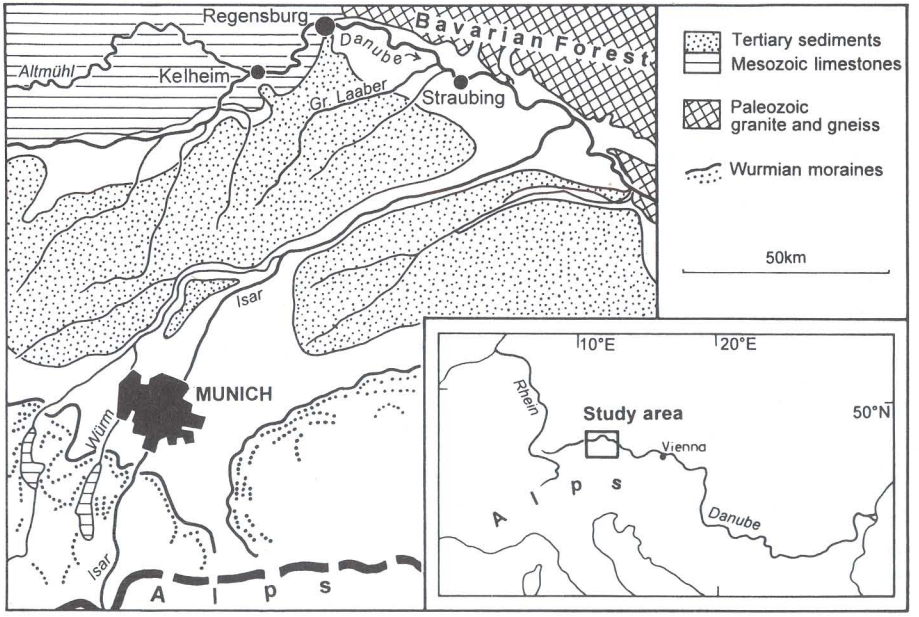


Figure 1. The study region of the Danube River near Regensburg, Germany.

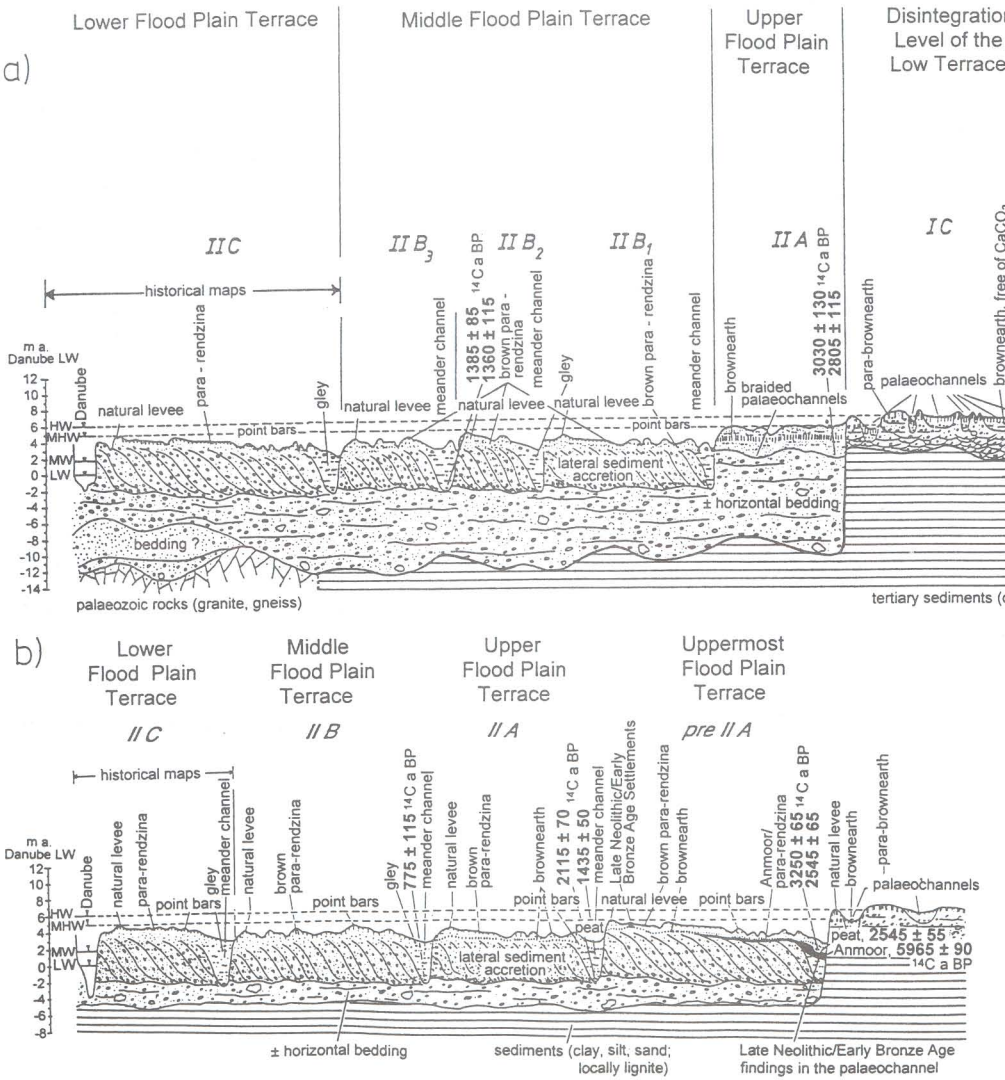
The general late Quaternary cycles of erosion and accumulation can be linked to the climatic cycles of the ice ages. The High Terrace ("Hochterrasse") corresponds to the penultimate glaciation ("Riss"), whereas the Low terrace ("Niederterrasse") was formed during the last glaciation (Würmian/Weichselian). Our detailed study of he sedimentation / erosion cycles prove that there is no direct response of the Danube River provide information of the rather complicated fluvial history in space and time (Fig.2-3).

The vertical aggradation of the gravel body of the Low Terrace ocurred prior to the last glacial maximum (LGM) and was completed before 26,000 C^{14} yrs BP. The accumulation of the Low Terrace gravels do not correspond to the LGM as is assumed by most scientists. The trasition from the cold (Weichselian) to the warm (Holocene) climatic epoch has been accompanied by a rather deep incision, followed by deposition. During the transition period, a high dynamic braided river system changed into a anastomosing , then into a low dynamic dynamic sinuous river system and again (together with deposition) to a high dynamic braided system (Fig 4). The incision started during the LGM. The rate of incision was greater in the Regensburg area than in the downstream (Straubing) and upstream (Kelheim) regions showing that the incision was markedly influenced by the shape of the Danube valley: where the stream abandons the Mesozoic limestone area, the valley widens, the gravels of the Low Terrace are thicker than down and upstream, and the erosion rate is 12 m compared to 6 m in the downsream area near Straubing and 4-5 m in the upstream (Kelheim) area . There is no indication that the different erosion levels of the Weichselian terraces (Main Level IB/NT_H and Disintegration Level IC/NT_E) were built up by different gravel bodies during the late glacial.

During the early and middle Holocene, the Danube River deposited the horizontally bedded gravels of the Upper Flood Plain Terrace. In the downstream (Straubing) area a readjustment of the river gradient was reached earlier than upstream documented by a transition from the braided system to a meandering system. This change of the river channel

pattern from the braided system to a meandering system. This change of the river channel pattern from braiding to meandering moved from the Straubing area upstream and reached the Regensburg area about 2000 years later. During the period with a meandering river system the lateral sediment acretion formed the different Flood Plain Terraces. The clear identification of a maximum of four (Straubing area) Flood Plain Terraces considerably contrasts with the differentiation of seven flood plain terraces by Schellmann (1994)in the same area . Our research results prove that the fluvial development of the Danube River is continuous and independent of the climatic rhythm during the Holocene. The reworking of the Flood Plain Terrace gravel is determined by the locally independent dynamics of meander development (Buch, 1988b). This type of "autogenic change"(according to Lewin 1977) controls the development of morphological and geological independent terraces .

Our studies on fluvial style changes of the Danube River near Regensburg show that it is the development of the fluvial system itself, starting from an initial disturbance impulse (e.g. transition from interglacial to glacial), wich triggers new reactions in the fluvial system and would finally lead via ana increasingly reduced oscillation to a static balance, in case that a new erosion / accumulation cycle is not stimulated before (Buch & Heine 1995). Therefore, time is not just historically understood. On the contary, time itself is na important factor in the process-response system(Buch 1988b).


a)
Lower Flood Plain Terrace
Middle Flood Plain Terrace
Upper Flood Plain Terrace
Disintegration Level of the Low Terrace
IIC
IIB3
IIB2
IIB1
IIA
IC
historical maps
m a. Danube LW
Danube
natural levee
para - rendzina
gley
meander channel
1385 ± 85 14C a BP
1360 ± 115
brown para - rendzina
brown para - rendzina
brownearth
braided palaeochannels
3030 ± 130 14C a BP
2805 ± 115
para-brownearth
palaeochannels
brownearth, free of CaCO3
HW
MHW
MW
LW
point bars
lateral sediment accretion
± horizontal bedding
bedding ?
palaeozoic rocks (granite, gneiss)
tertiary sediments (
b)
Lower Flood Plain Terrace
Middle Flood Plain Terrace
Upper Flood Plain Terrace
Uppermost Flood Plain Terrace
IIC
IIB
IIA
pre IIA
historical maps
m a. Danube LW
Danube
natural levee
para-rendzina
point bars
gley
meander channel
brown para-rendzina
775 ± 115 14C a BP
brownearth
2115 ± 70 14C a BP
1435 ± 50
Late Neolithic/Early Bronze Age Settlements
Anmoor/ para-rendzina
3250 ± 65 14C a BP
2545 ± 65
peat
peat, 2545 ± 55
Anmoor, 5965 ± 90 14C a BP
± horizontal bedding
sediments (clay, silt, sand; locally lignite)
Late Neolithic/Early Bronze Age findings in the palaeochannel

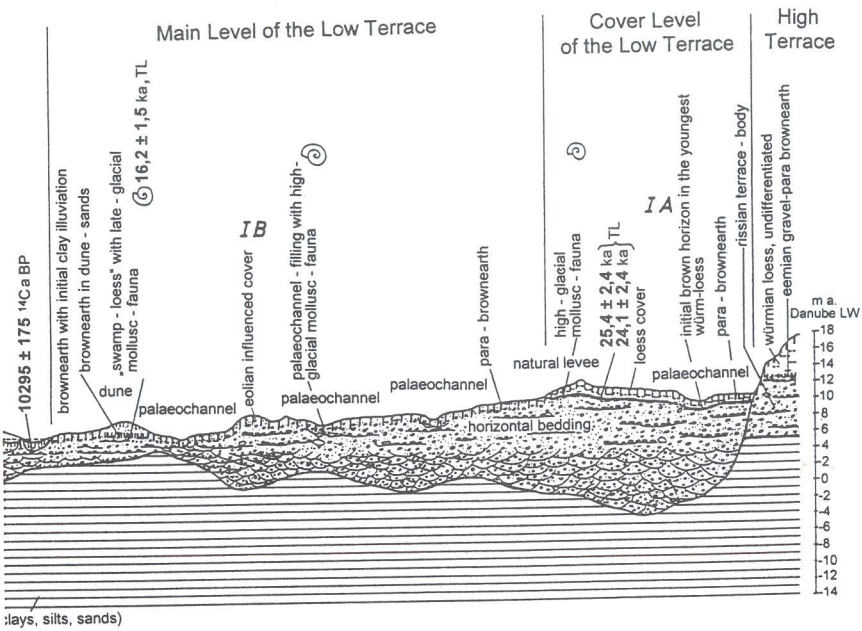


Fig. 2. Cross-section of the Würmian/Weichselian and Holocene system of valley floor terraces of the Danube River (a) in the Regensburg area and (b) downstream in the Straubing area (after BUCH & HEINE 1995).

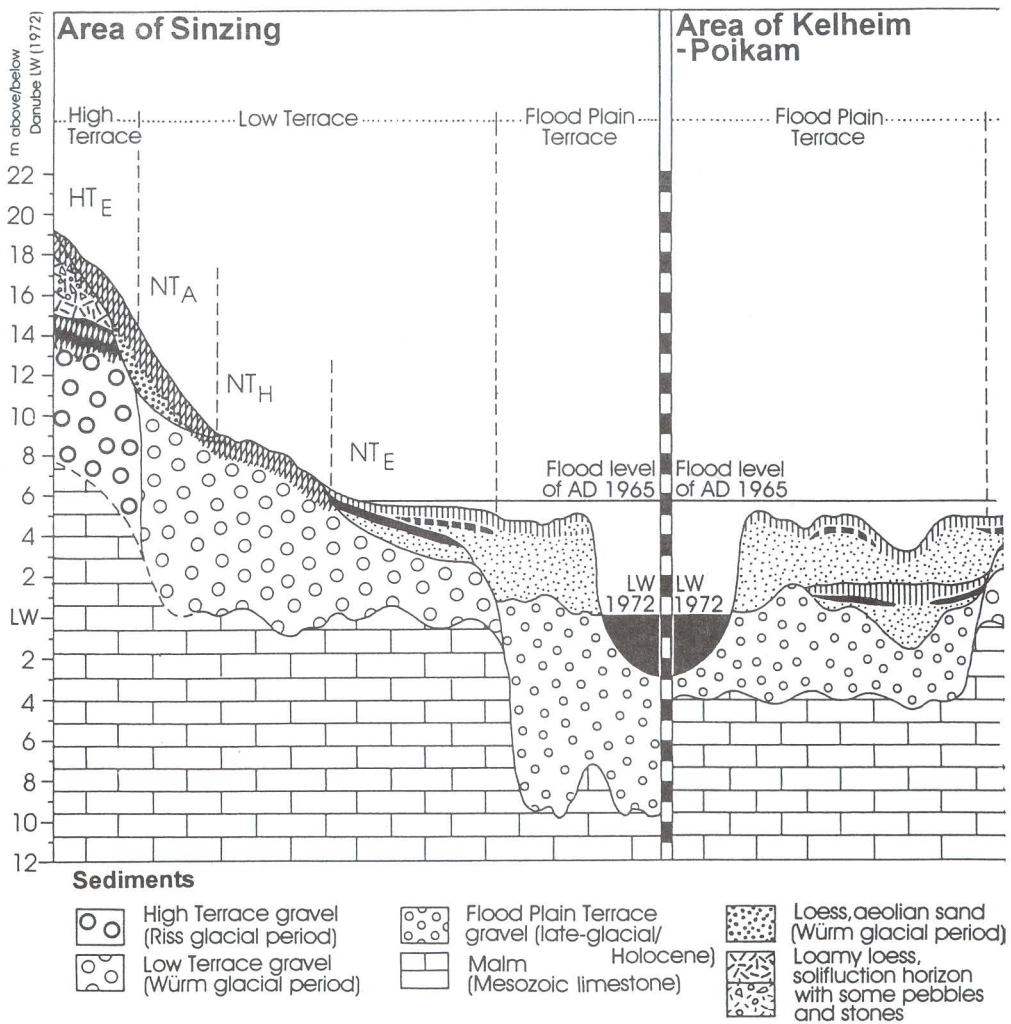
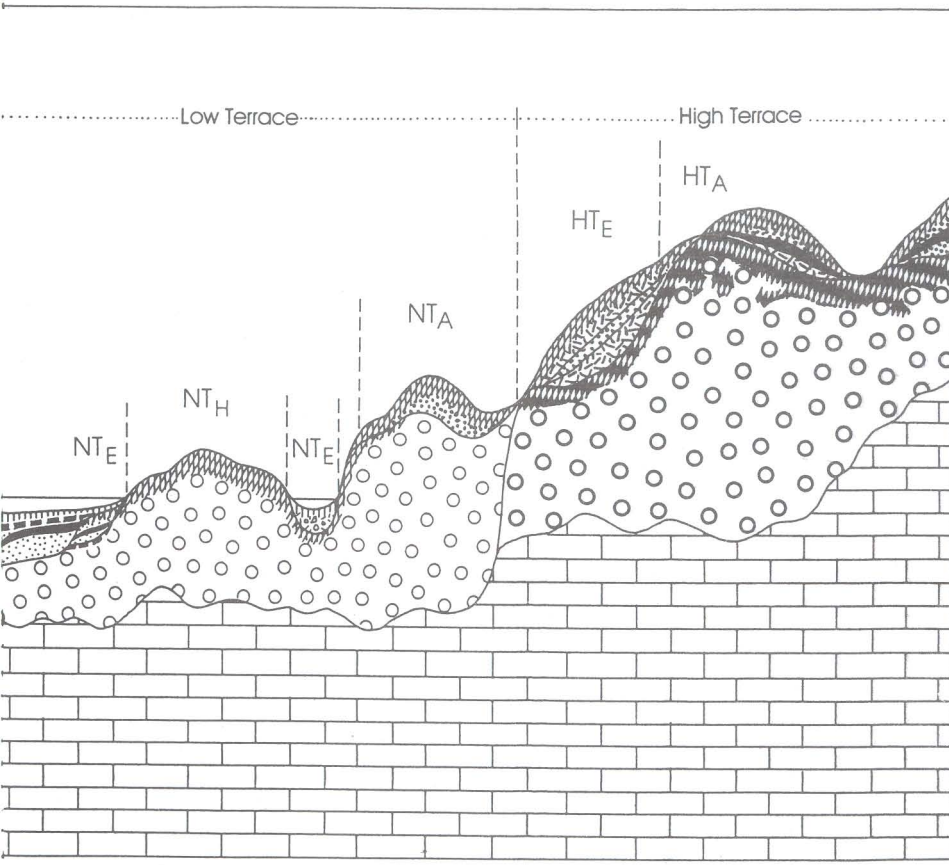


Fig. 3. Cross-section of the late Quaternary system of valley floor terraces of the Danube River between Sinzing and Kelheim (upstream of Regensburg) (after HILGART 1995).



Flood sediments

Colluvial sediments, Holocene

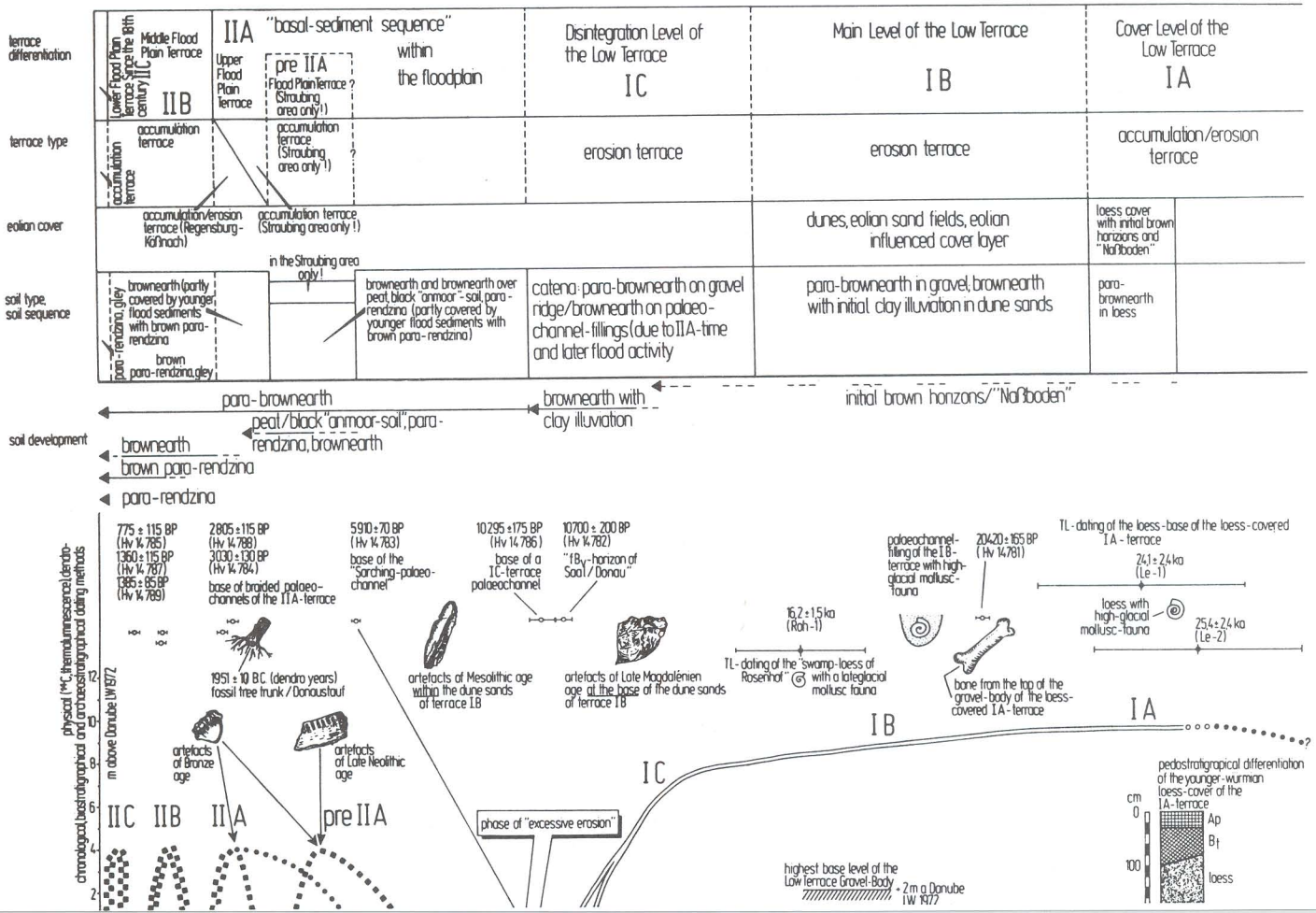
Para - brownearth

Bt - horizon

Ah - horizon

Bv - horizon

Cv - horizon


terrace differentiation
Lower Flood Plain Terrace Since the 18th century
Middle Flood Plain Terrace
IIB
accumulation terrace
IIA
"basal-sediment sequence" within the floodplain
Upper Flood Plain Terrace
pre IIA
Flood Plain Terrace ? (Straubing area only!)
Disintegration Level of the Low Terrace
IC
Main Level of the Low Terrace
IB
Cover Level of the Low Terrace
IA
terrace type
accumulation terrace
accumulation terrace (Straubing area only!)
erosion terrace
erosion terrace
accumulation/erosion terrace
eolian cover
accumulation/erosion terrace (Regensburg-Kößnach)
accumulation terrace (Straubing area only!)
dunes, eolian sand fields, eolian influenced cover layer
loess cover with initial brown horizons and "Naßboden"
soil type, soil sequence
in the Straubing area only!
brownearth (partly covered by younger flood sediments with brown para-rendzina
brown para-rendzina, gley
para-rendzina, gley
brownearth and brownearth over peat, black "anmoor"-soil, para-rendzina (partly covered by younger flood sediments with brown para-rendzina)
catena-para-brownearth on gravel ridge/brownearth on paleo-channel-fillings (due to IIA-time and later flood activity
para-brownearth in gravel, brownearth with initial clay illuviation in dune sands
para-brownearth in loess
soil development
para-brownearth
brownearth with clay illuviation
initial brown horizons/"Naßboden"
peat/black "anmoor-soil", para-rendzina, brownearth
brownearth
brown para-rendzina
para-rendzina
775 ± 115 BP (Hv 14.785)
1360 ± 115 BP (Hv 14.787)
1385 ± 85 BP (Hv 14.789)
2805 ± 115 BP (Hv 14.788)
3030 ± 130 BP (Hv 14.784)
base of braided paleo-channels of the IIA-terrace
5910 ± 70 BP (Hv 14.783)
base of the "Sarching-paleo-channel"
10295 ± 175 BP (Hv 14.786)
base of a IC-terrace paleochannel
10700 ± 200 BP (Hv 14.782)
"1Bv-horizon of Saal/Donau"
paleochannel-filling of the IB-terrace with high-glacial mollusc-fauna
20420 ± 165 BP (Hv 14.781)
TL-dating of the loess-base of the loess-covered IA-terrace
24,1 ± 2,4 ka (Le-1)
loess with high-glacial mollusc-fauna
25,4 ± 2,4 ka (Le-2)
16,2 ± 1,5 ka (Roh-1)
TL-dating of the "swamp-loess of Rosenhof" with a lateglacial mollusc fauna
1951 ± 10 B.C. (dendro years) fossil tree trunk / Donaustauf
artefacts of Mesolithic age within the dune sands of terrace IB
artefacts of Late Magdalénien age at the base of the dune sands of terrace IB
bone from the top of the gravel-body of the loess-covered IA-terrace
artefacts of Bronze age
artefacts of Late Neolithic age
IIC
IIB
IIA
pre IIA
IC
IB
IA
phase of "excessive erosion"
highest base level of the Low Terrace Gravel-Body
+ 2 m a. Danube LW 1972
physical (14C, thermoluminescence), dendro-chronological, biostratigraphical and archaeostratigraphical dating methods
m above Danube LW 1972
pedostratigrapical differentiation of the younger-wurmian loess-cover of the IA-terrace
cm
0
100
Ap
Bt
loess

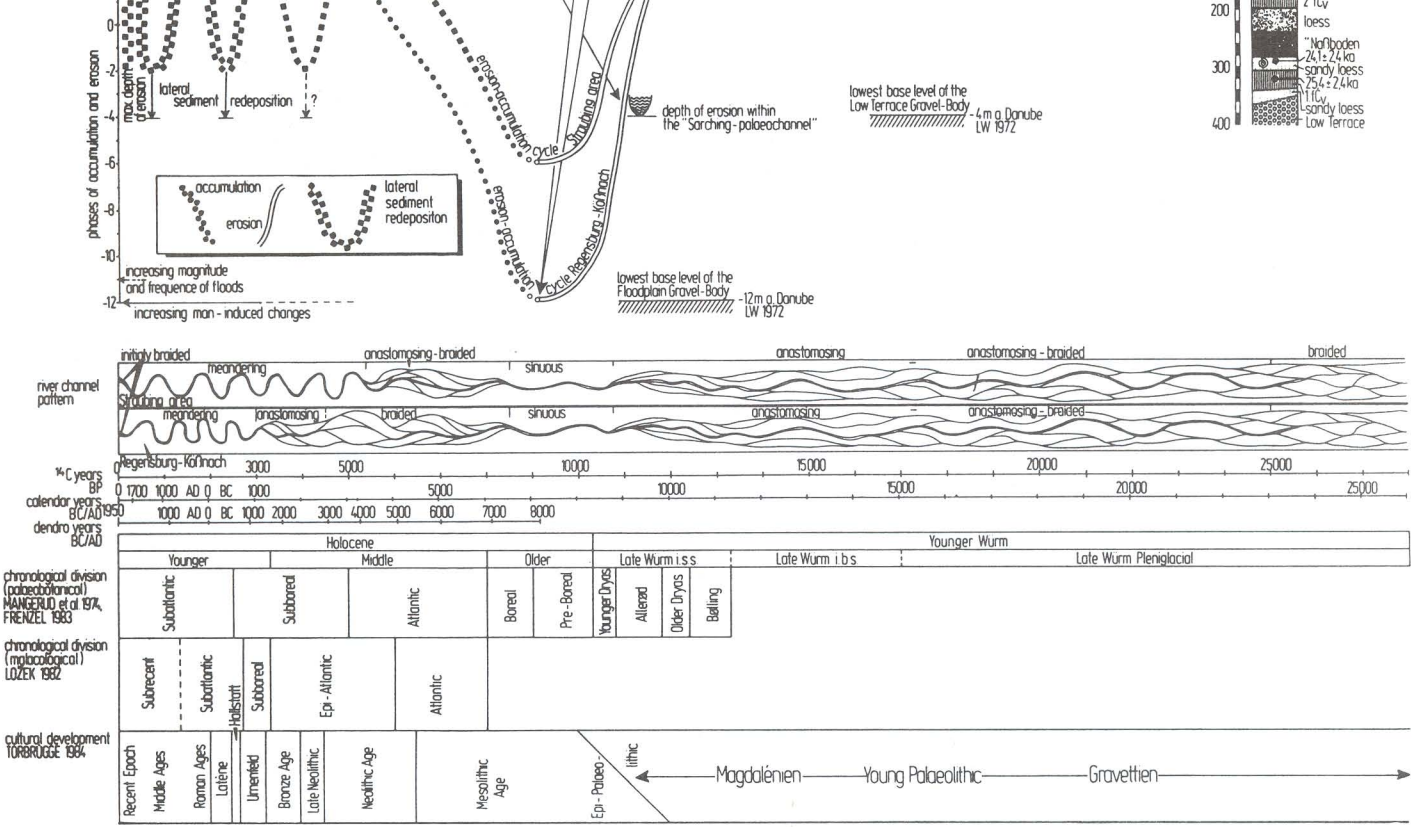


Fig. 4. Late Quaternary fluvial geomorpholodynamics in the Danube River Valley between Regensburg and Straubing (after BUCH & HEINE 1995).

References

Buch, M,W. (1988[a]) :Spätpleistozäne und holozäne fluviale Geomorphodynamik im Donautalzwischen Regensburg und Straubing.-Regensburger Geographische Schriften **21 I/II :** 1-197 and supplement . Regensburg.

Buch, M,W. (1988b) Zur Frage einer kausalen Verknüpfung fluvialer Prozesse und Klimaschwankungen im Spätpleistozän und Holozän – Versuch einer geomorphodynamischen Deutung von Befunden von Main und Donau.-Zeitschrift Geomorphologie, Suppl.-Band **70 :** 131-162.

Buch, M,W. & K.Heine (1995): Fluvial geomorphodynamics in the Danube River valley and tributary river systems near Regensburg during the Upper Quaternary – theses , questions ans conclusions.-Zeitschrift Geomorphologie, Suppl.-Band **100**: 53-64.

Heine K. (in press): FlieBgewässer und FluBauen – geologisch –geomorphologische Betrachtungen.-Relief.-Boden – Paläoklima **14**. Stuttgart.

Hey, R.D. (1979): Dynamic process-response model of river channel development .-Earth Surface Processes and Landforms **4**: 59-72.

Hilgart, M.(1995): Die geomorphologische Entwicklung des Altmühl- und Donautales im Raum Dietfurt –Kelheim-Regensburg im jüngeren Quartär.- Forschungen zur deutschen Landeskunde **242**; 1-336. Trier

Lewin, J. (1977): Channel pattern changes . In:Gregory, K.J.(eds), River Channel Changes : 221-233. Chichester- Wiley.

Peterhoff, F. (1986) : Morphologische Untersuchungen zur Talgeschichte

des mittleren Regens.-Umpubl.Ph.D.Theses, University of Regensburg , Phil. Fak.III, 1-181 and supplement.

Schellmann, G. (1994): Wesentliche Steuerungsmechanismen würmzeitleicher und holozäner FluBdynamik im deutschen Alpenvorland und Mittelgebirgsraum.-Düsseldorfer Geographische Schriften **34 :** 123-146