Results of recent Terrace Research in the Middle Rhine Valley

Fig. 1.: Downstream Correlation Diagram of River-Terraces in the Lower Nahe & Upper Middle Rhine Valley.

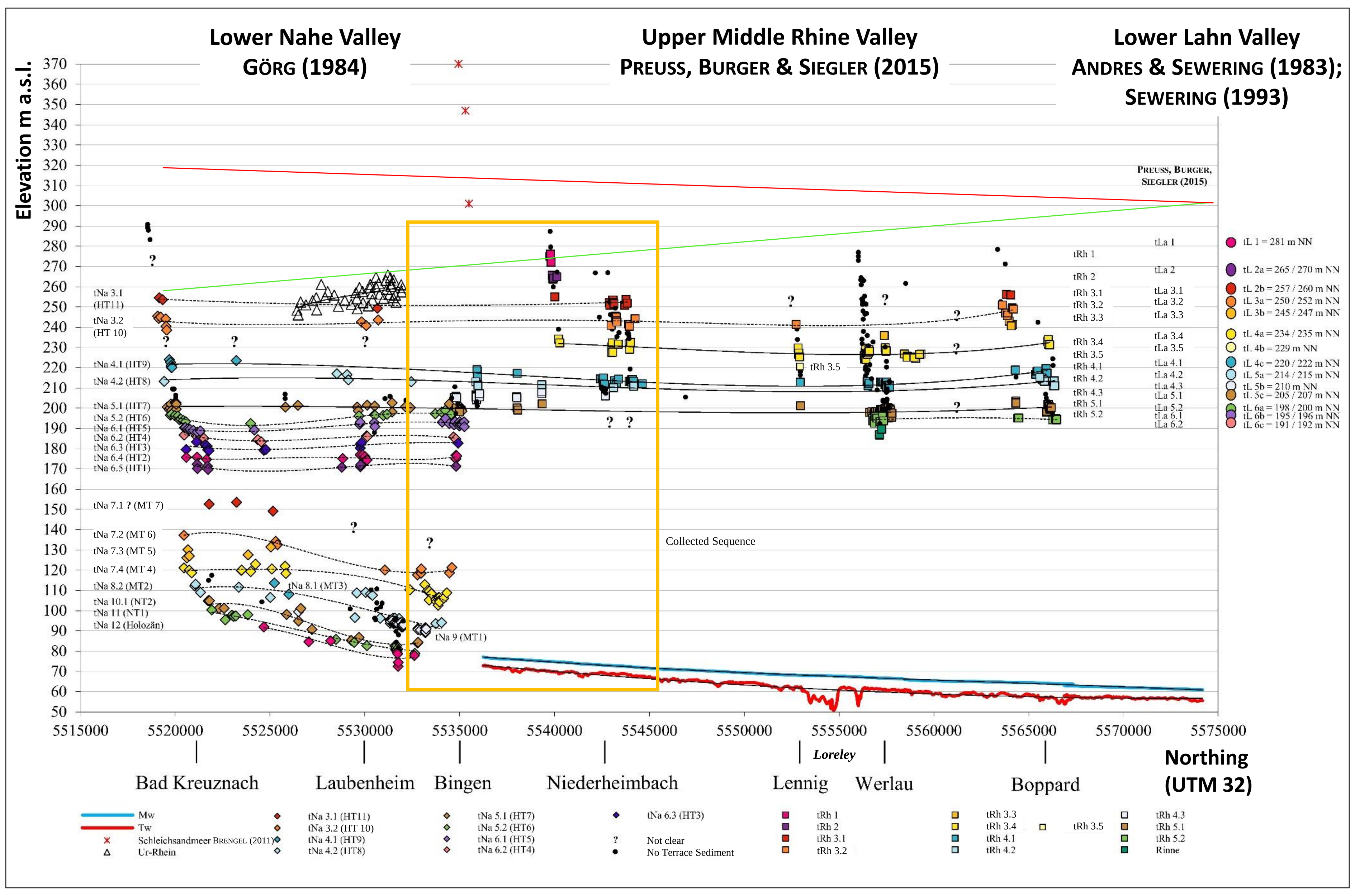
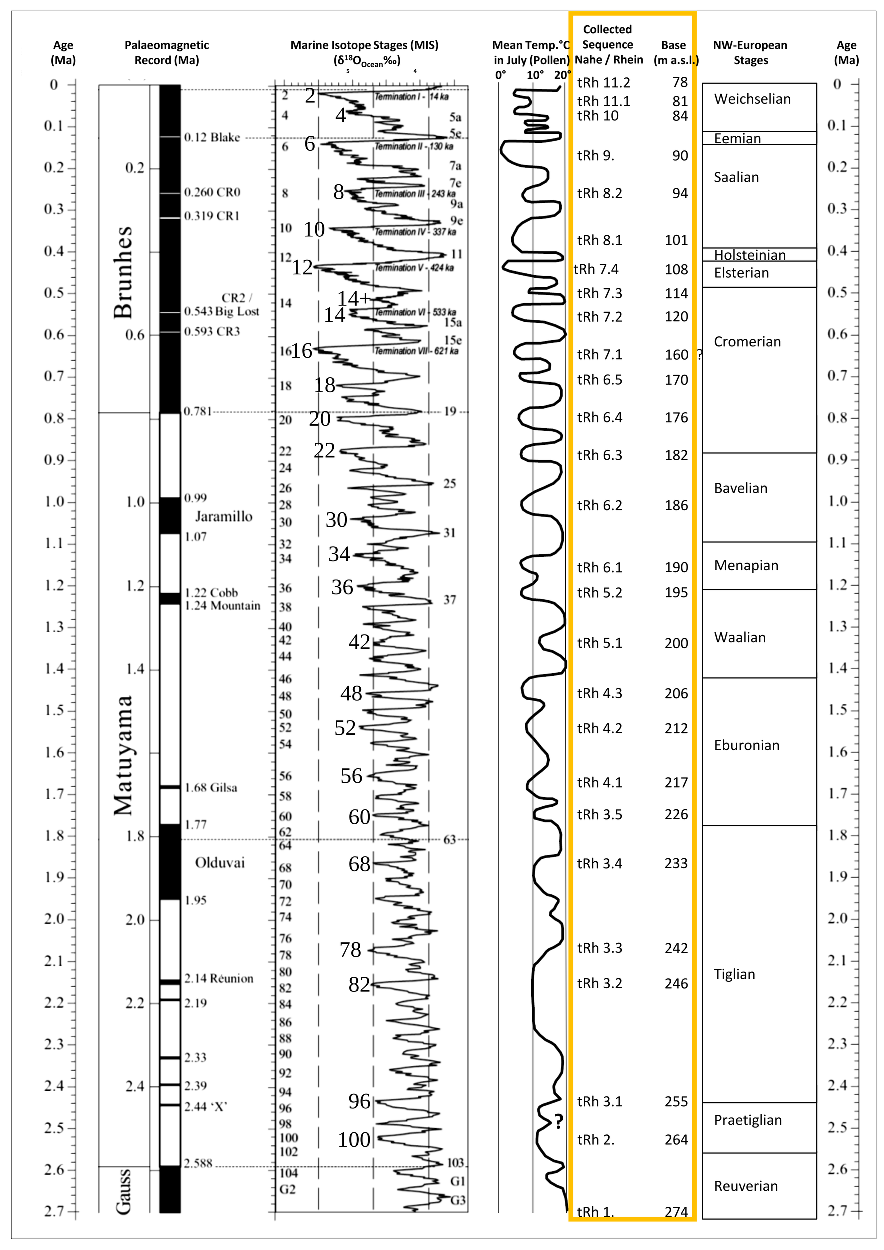


Fig. 2 & Tab. 1: Collected Sequence of the Rhine and Nahe Terraces at Bingen-Trechtingshausen correlated with Pollen Records and Marine Isotope Stages.



Terrace-labels Nahe / Rhine	MIS (No.)	Elevation of Terr. Base Nahe/Rhine (m a.s.l.)	Assumed Mean Age (Ma)	Difference in Age Nahe/Rhine (Ma)	Incision at Collected Sequence Nahe/Rhine (mm/a)
tNa 12.	1	75	0,00	0,01	0,30
tNa 11.2	1-2	78	0,01	0,01	0,30
tNa 11.1	2	81	0,02	0,04	0,08
tNa 10.	4	84	0,06	0,08	0,08
tNa 9.	6	90	0,14	0,11	0,04
tNa 8.2	8	94	0,25	0,09	0,08
tNa 8.1	10	101	0,34	0,10	0,07
tNa 7.4	12	108	0,44	0,07	0,09
tNa 7.3	14+	114	0,51	0,03	0,20
tNa 7.2	14	120	0,54	0,09	0,44
tNa 7.1	16	160	0,63	0,08	0,13
tNa 6.5	18	170	0,71	0,08	0,08
tNa 6.4	20	176	0,79	0,08	0,08
tNa 6.3	22	182	0,87	0,17	0,02
tNa 6.2	30	186	1,04	0,08	0,05
tNa 6.1	34	190	1,12	0,07	0,07
tRh 5.2	36	195	1,19	0,13	0,04
tRh 5.1	42	200	1,33	0,11	0,05
tRh 4.3	48	206	1,45	0,08	0,08
tRh 4.2	52	212	1,53	0,12	0,04
tRh 4.1	56	217	1,65	0,10	0,09
tRh 3.5	60	226	1,75	0,11	0,06
tRh 3.4	68	233	1,86	0,21	0,04
tRh 3.3	78	242	2,07	0,09	0,04
tRh 3.2	82	246	2,16	0,27	0,03
tRh 3.1	96	255	2,43	0,09	0,10
tRh 2.	100	264	2,52	0,19	0,05
tRh 1.	G4	274	2,71	-	-

Figure 1: The DCD of river terraces in the Lower Nahe and Upper Middle Rhine Valley contains 28 alluvial sediment bodies. They were identified at key locations with the help of more than 720 borehole drillings, many of them in clusters, which in most cases reached the rockbed of the river terraces. The field work was based on contour level maps derived from a LIDAR terrain model. The older study at the Nahe (GÖRG 1984) was based on the German Basic Map, scale 1:5,000 ("Deutsche Grundkarte 1:5.000"). Our findings show that the upper group of terraces consist of at least 17 clearly distinguishable terrace levels, which correspond to the sequences of the Nahe and Lahn valleys (GÖRG 1984, SEWERING 1993). Taking the results of Görg (1984) into account, further 11 levels can be identified below the jHT in the Lower Nahe Valley. In Fig. 1 the gradients of the Palaeo-Rhine (see the triangles between 240-270 m a.s.l.) are inversely inclined to the river´s current flow of direction - namely to the south, river terraces between 200 m a.s.l. and 170 m a.s.l. are arranged more or less horizontally and river terraces below 140 m a.s.l. have a normal gradient to the north. This diagram shows that the hypothesis of a missing gradient is obsolete, but at the same time the longitudinal gradients are obviously affected by tectonic processes (see green line).

Fig. 3.: Comparison of the collected Chronosequence of Nahe and Rhine with the Chronosequence of the Maas, with Pollen Records and Marine Isotope Stages.

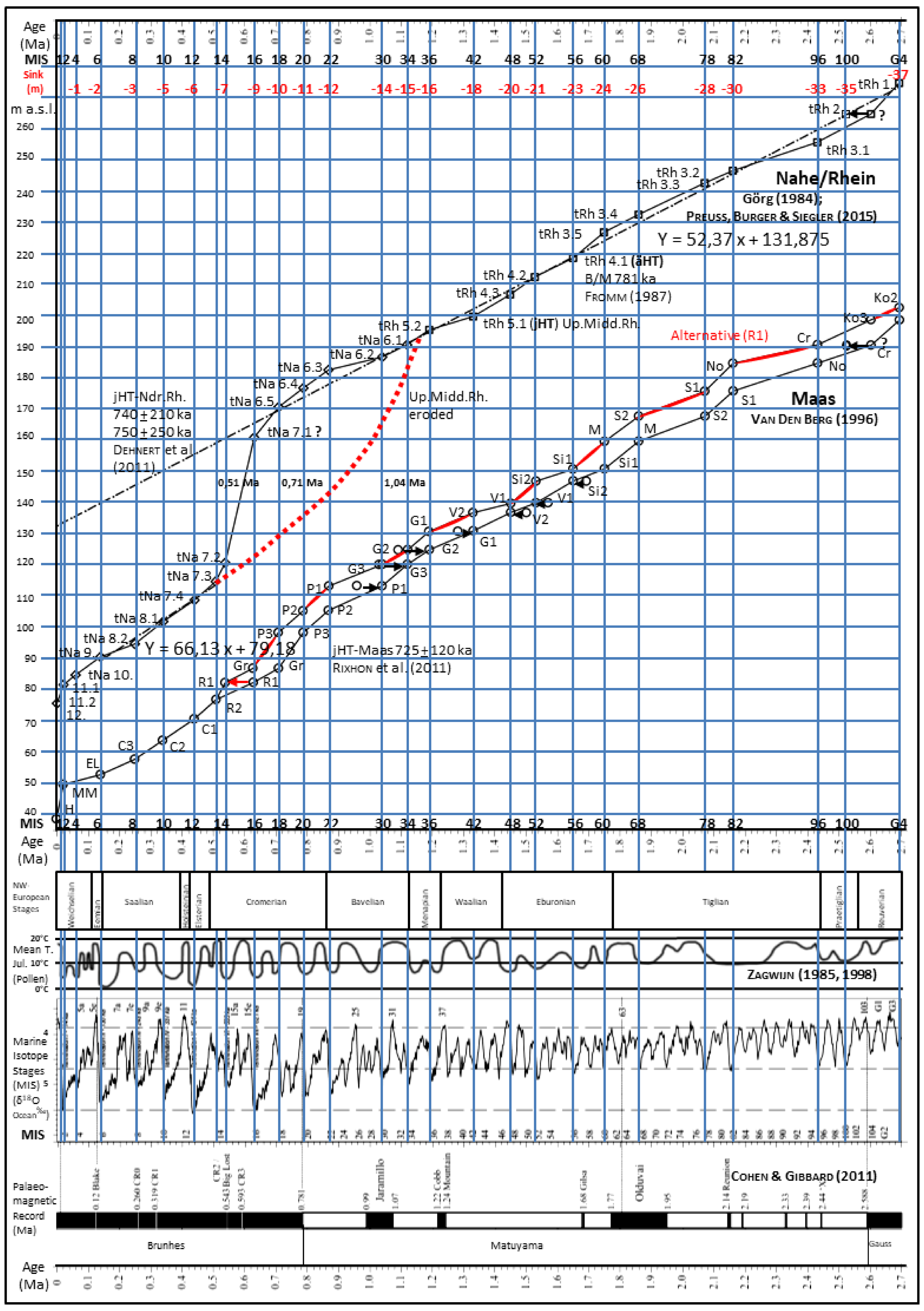


Fig. 4.: Contour Lines of Height Changes and of the Crust-Mantle Boundary, Epicentres of Earthquakes, and Slope Inclination.

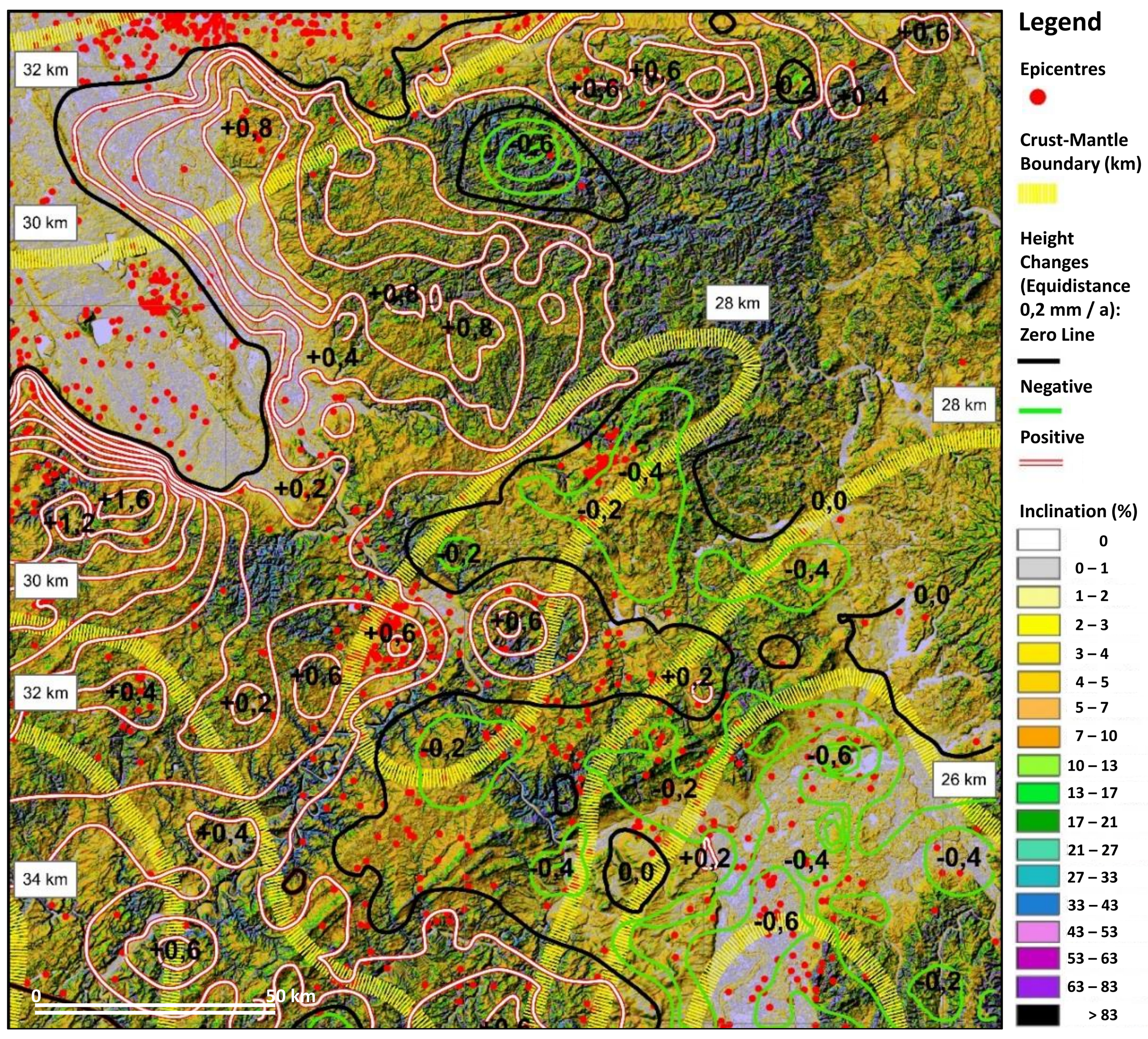


Figure 2: Using the idea of VAN DEN BERG (1996), a collected sequence of Nahe and Rhine terraces was arranged at Rhine-kilometre 533, using their discernible trends. The "elevations of the terrace bases" from this collected sequence were matched to the cold periods of the thermal interpretation of the results of pollen analysis in the Netherlands (ZAGWIJN 1985, 1998), which in turn were correlated to the diagram of the Marine Isotope Stages (COHEN & GIBBARD 2011). Using this approach, we obtained a correlation with climatic events of the last 2.7 million years, the standard NW-European Stages and an approximate age for the river terraces.

Tab 1: From Fig. 2 several relevant information was extracted (terrace-labels, MIS, elevation of the terrace base, assumed mean age) and new information was calculated (difference in age, incision rate for the collected sequence).

Figure 3: Two linear trends are visible in the diagram, one between 0.7 Ma and 2.7 Ma, the other between 0.14 Ma and 0.5 Ma. The gradients of the linear equations are 52.37 m/Ma for the older and 66.13 m/Ma for the younger period. These values are fluvial incision rates, but they can be interpreted as tectonic uplift rates as well. The difference of 14 m/Ma is interpreted as a subsidence rate of the collected chronosequence. Of further interest is the period between 1.04 Ma and 0.51 Ma, which marks an excessively changing environment, visible in the climatic records and in the incision rates.

Fig. 5.: Geomorphological Map of River Incision.

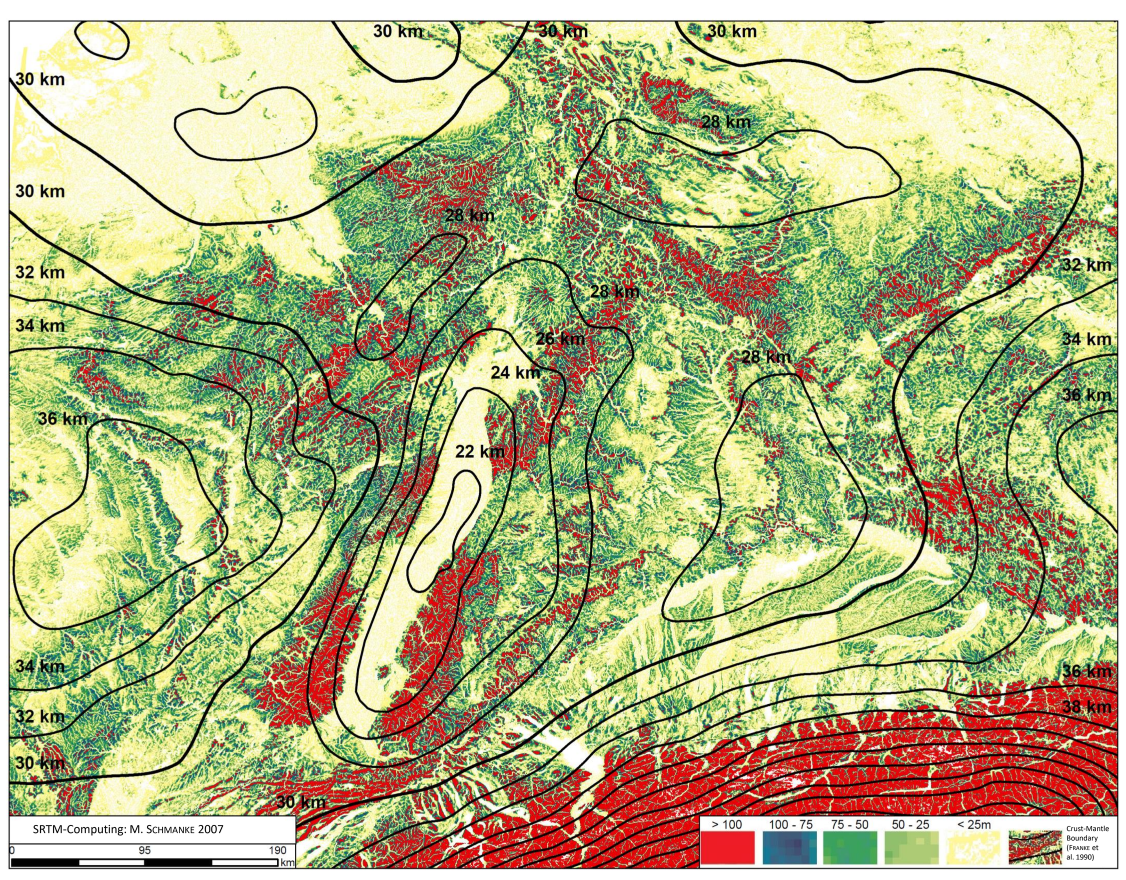


Figure 4: An explanation model for the changes in slope of the longitudinal gradients of the terraces of the upper terrace group could be derived by considering the direction and the amount of recent crustal movements in this area, which have been measured by MÄLZER et al. (1983) with the help of precision levellings. Uplift processes can be observed north of the mouth of the Lahn, and subsidence processes southeast of it. The course of the River Rhine is thus located in a zone of crust which is inclining contrary to the gradient of flow, with values increasing towards the Upper Rhine Graben. From there the research area is uplifted and partly lowered, depending on geotectonic processes of the Upper Rhine Rift Valley in the south and southeast, and the graben of the Cologne Bay in the northwest. To visualize and localize the tectonic processes, the crust-mantle boundary and epicenters were integrated (FRANKE et al. 1990; USSGS 2002; LEYDECKER 2005).

Fig. 6.: Terrace Model of the Middle Rhine Valley.

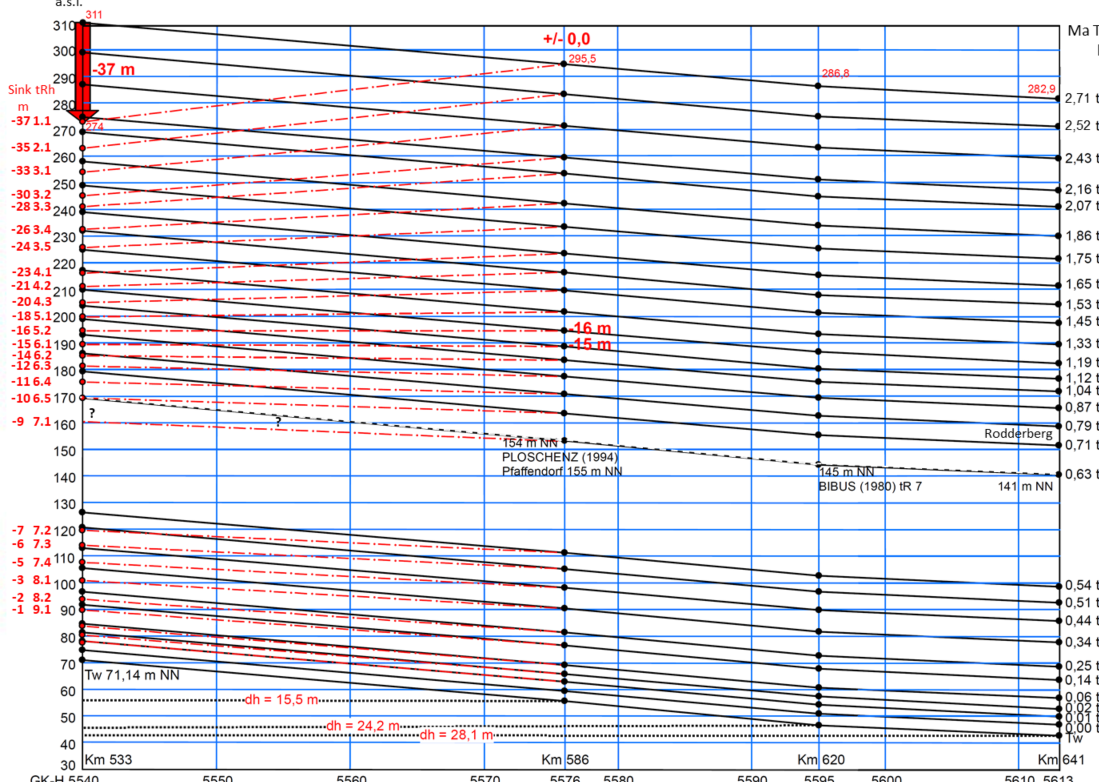


Fig. 7.: Evaluation of the Terrace Model with two Datasets from the Lower Middle Rhine Valley.

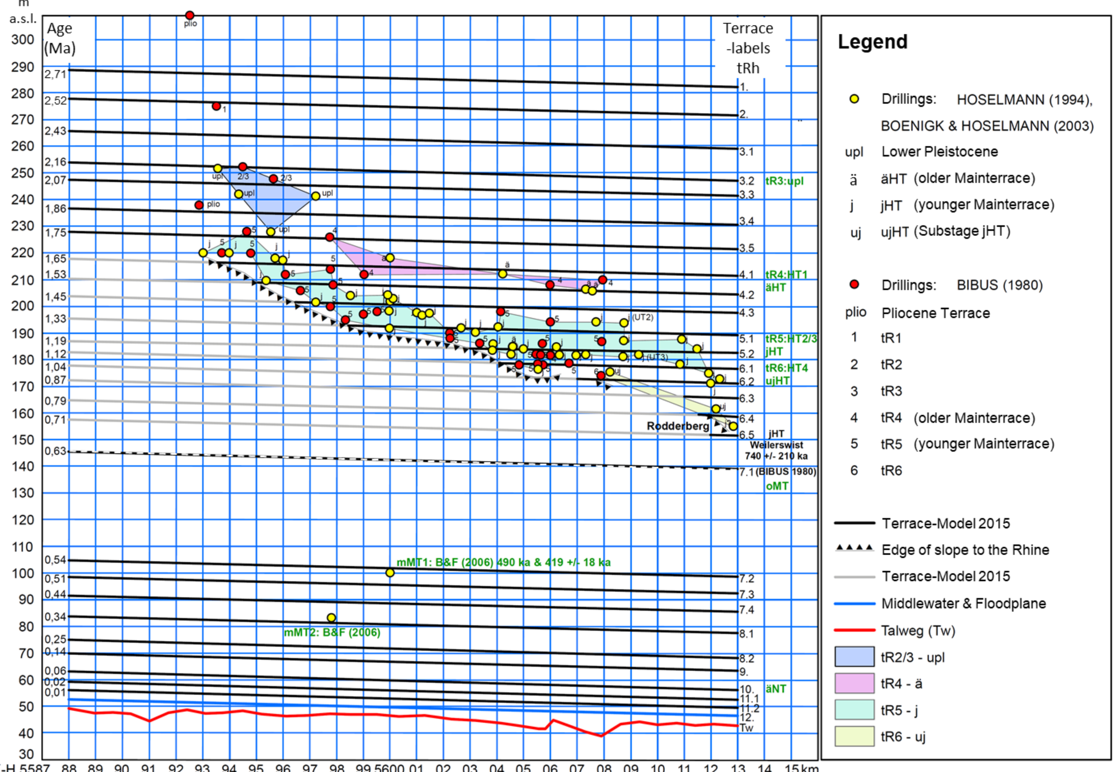


Figure 5: The tectonic setting can be visualized with a geomorphological map of river incisions. In it we see the consequences of the collision of Africa and Europe, the uplift of the Alps, the creation of the uplifted uplands to their north and the Rhine Graben. The river incision is the calculated difference between the base of the relief, i.e. the tangential plain to the thalweg of the valleys, and the SRTM-topography. The valleys in uplifted areas as the Alps, the Vosges, the Black Forest etc. are deep (> 100 m, red), in the uplands the incision of the rivers is mainly 75-50 meters (dark green). The crust-mantle boundary visualizes and localizes the tectonic processes.

Figure 6: A simple model could be calculated and designed with data from the collected chronosequence of Nahe and Rhine terraces, especially with the calculated subsidence rate of 14 m/Ma. With it the terraces could be virtually uplifted again. The base of the tRh 1. is actually at 274 m a.s.l. and has been lowered by 37 m within 2.71 Ma. Therefore the thalweg back then was positioned at 311 m a.s.l. Finally, the actual height of the rockbeds of the terraces of the collected sequence were connected to the heights of the mouth of the Lahn with red lines. The graphical result is more or less the same picture as in the Downstream Correlation Diagram (DCD) (Fig. 1.). The missing gradient of some river terraces is therefore the product of the subsidence of the Middle Rhine Valley.

Figure 7: The terrace model was evaluated with two datasets from the Lower Middle Rhine Valley (BIBUS 1980, HOSELMANN 1994). We could observe that the test data fits quite well into the framework of the model. Therefore we think that the ages of the terraces, based on their correlation with the data of ZAGWIJN (1985, 1998) and COHEN & GIBBARD (2011) are quite good and representative.

Source: PREUSS, J., BURGER, D. & SIEGLER, F.: Neue Ergebnisse zur Gliederung und zum Längsgefälle der Talbodenniveaus im Mittelrheintal und an der Unteren Nahe: Revision der Hypothese der Niveaukonstanz, Berücksichtigung des Modells der aktuellen Höhenänderungen, Korrelation der Terrassensequenz mit den Marinen Isotopen Stadien und den Terrassen der Maas. Mainzer naturwissenschaftliches Archiv, Band 52, S. 5-75, 19 Abb., 8 Tab., Mainz, 2015.

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