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Loess at foot slope position in the Northern Franconian Alb (Germany)

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Abstract

The 2 m thick Wannbach section of sandy loess is situated on a river terrace of the penultimate glacial period. The terrace belongs to a small tributary valley connected to the Rhine River system. The section at foot slope position is situated close to the valley bottom, where on top of the gravel terrace, a tightly linked luvisol paleosol complex could develop, followed by a sandy loess. The high sand content of the loess of ca. 30% can be explained by the morphological position of the section below a Middle Jurassic sandstone layer of an escarpment close to Wannbach. A nearby loess section 1.5 km away from the escarpment shows a normal sand content of ca. 5%, whereas the low coarse silt content (63–20 µm) of both, the loess and sandy loess section, is typical of the sandy and clayey Mesozoic rocks of the study area, which is situated in the hinterland of the large river basins of the Rhine and Danube rivers. Concerning the age of the sandy loess from the Wannbach section, the rich presence of gelic gleysols and optically stimulated luminescence (OSL) data between 30 and 50 ka point to an earlier Weichselian age.

Kurzfassung

Das gut 2 m mächtige Sandlössprofil Wannbach liegt auf einer talgrundnahen spät-saalezeitlichen Terrasse des kleinen Thoosbaches, der über Trubach-Regnitz-Main rheintributär ist. Auf der Terrasse liegt unter dem Sandlöss ein Bodenkomplex aus letztinterglazialer Parabraunerde. So sollte der Sandlöss darüber letztglazial sein.
Sein Sandanteil (besonders Feinsand) von ca. 30% resultiert aus der darüber liegenden braunjura-zeitlichen Eisensandstein-Stufe. In 1,5 km Entfernung von der Stufe liegt normaler Löss mit 5% Sandanteil. Der ansonsten geringe Grobschluffgehalt (63–20 µm) dieses Lösses und Sandlösses ist typisch für das ostfränkische Lössgebiet auf sandig-tonigem mesozoischen Untergrund. Nassbodenreichtum und OSL-Alter zwischen 30 und 50 ka des Profils Wannbach sprechen für ein älteres weichselzeitliches Alter des Sandlösses.

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1 Introduction

A loess section at foot slope position of the Jurassic escarpment uprising 200 m, provokes the examination, how grain size and luminescence ages would react under the influence of fine debris input from above. In this special case examined here, it is the fine sand and silt from the “Eisensandstein” (Middle Jurassic sandstone), which occurs as a 60 m thick bed 15 m above the described loess section. During periglacial conditions, the sand was washed downslope, and fine sand and silt was drifted around the slope by strong winds.

The Franconian Alb forms a plateau topped by Jurassic limestone and dolomite of up to 250 m thickness. The karstic plateau rises up to 500–600 m a.s.l. and is dissected by 250–300 m deep valley incisions, with valley bottoms at 260–300 m a.s.l. During the Pleistocene, the plateau as well as the valleys were affected by loess influx (SCHIRMER 1967, 2010, KRISL 1997, FUCHS et al. 2011, and various geologic maps as ANTONIADIS et al. 1972).
In this paper the loess at the valley flanks is discussed, which is preserved at slope toes, in both, luv and lee positions.

The Alb plateau was covered by loess at least during the Middle and Late Pleistocene. The maximum loess cover exhibits 4 m of limestone bearing loess, containing at least four pedo-lithological glacial-interglacial cycles. Each of the last pedo-lithological cycles starts with an early glacial stony solifluction layer, followed by a pleniglacial loess with tapering layers of rock fragments and ending with an interglacial fossil soil (SCHIRMER 2016a).

In contrast to the plateau, sediments from foot slope positions are often subject to strong geomorphological sediment reworking. Thus, the question arises whether older loess deposits were affected by erosion and the loess deposits themselves, contain reworked sediments from older periods of loess deposition. This important aspect needs to be considered, when loess at foot slope position is used as a proxy for paleoenvironments. In this case, a reliable chronology is of great importance, with luminescence dating as a dating method, which allows to date the last process of sediment reworking.

2 Study area and profile description

The Wannbach section is located in the Trubach valley, a tributary to the Wiesent River and connected to the Rhine-Main drainage system (Fig. 1). It is exposed to the small Thoosbach valley facing southeast and situated at slope toe position close to the valley bottom, 50 m before the Thoosbach valley merges with the Trubach valley (Fig. 1+2).

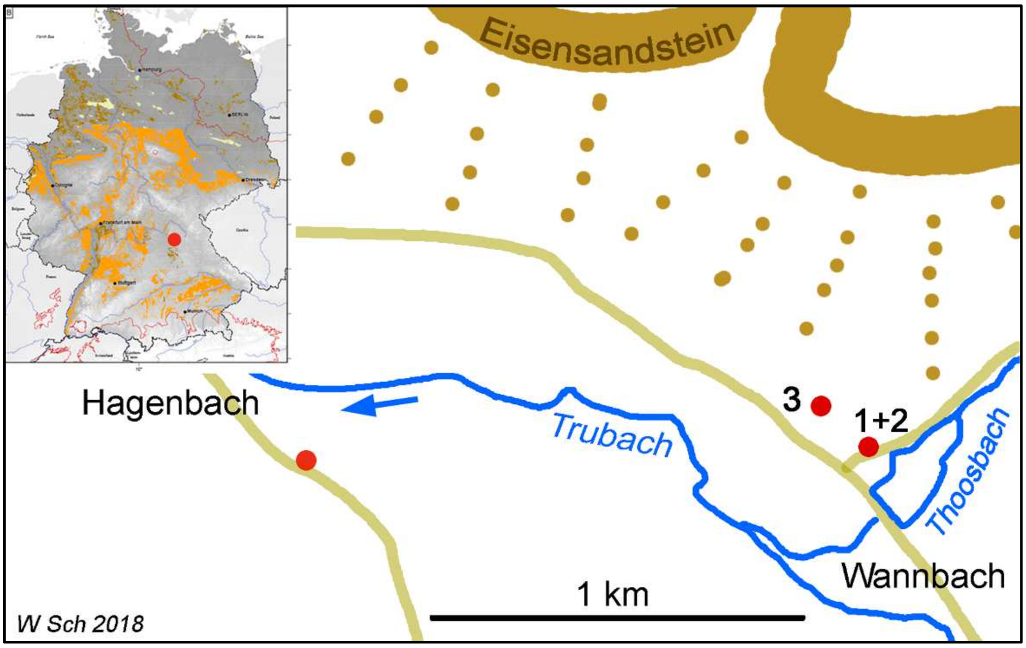


Figure 1: Location map of the area Wannbach and Hagenbach (Upper Franconia). Red dots are the places of sampling: Wannbach 1+2 and 3 below the outcrop of the Eisensandstein, and Hagenbach away from the slope with Eisensandstein debris. The inset map shows the investigation area (red dot) within the loess distribution of Germany after LEHMKUHL et al. (2018).

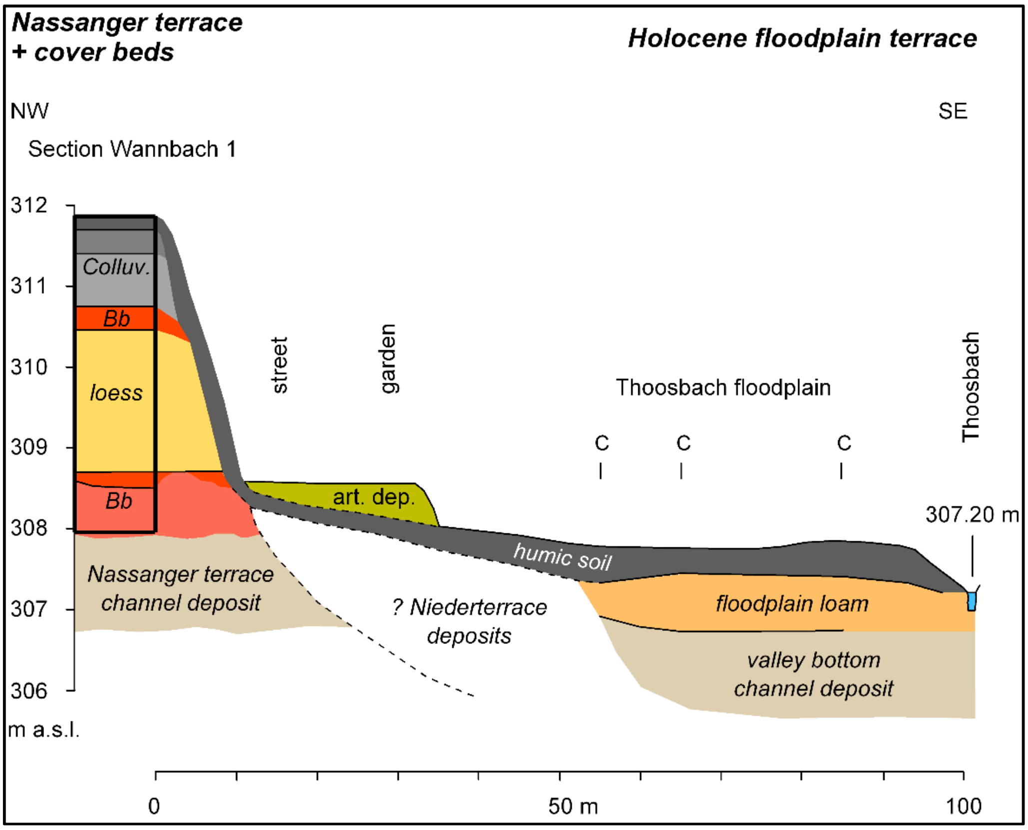
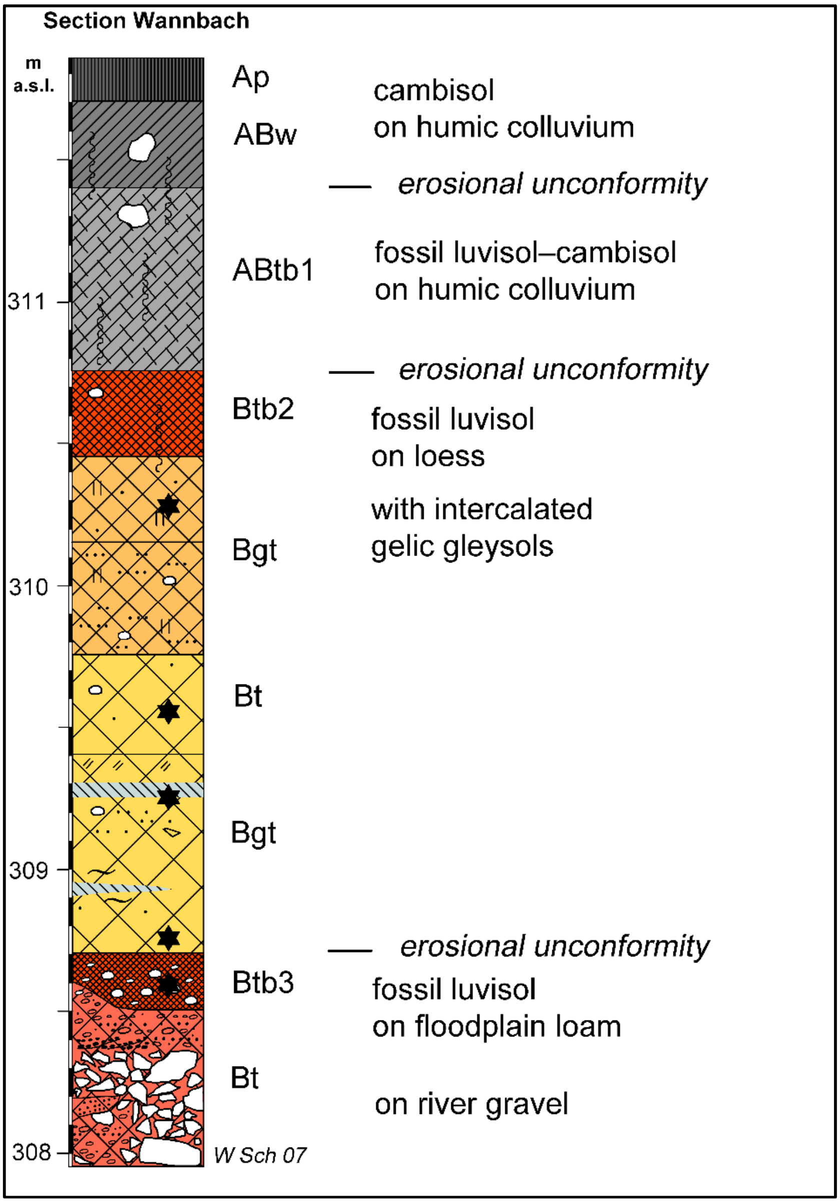


Figure 2: Cross section of the Thoosbach valley and the Wannbach section 1. C = hand corings in the floodplain. Bb = fossil soil, the upper one of early Holocene age, the lower one of Eemian+lower Würmian age; art. dep. = artificial deposit.

Four sampling sites were investigated:
Section Wannbach 1 (Fig. 1-3) for luminescence sampling (BT 696-698, BT 990-991).
Section Wannbach 2 (Fig. 1) for grain size sampling (No. Alb 377–381).
Sample Wannbach 3 (Fig 1) for grain size sampling (No. Alb 403).
Sample Hagenbach (Fig. 1) for grain size sampling (No. Alb 404).

The profile Wannbach 1 shows the following stratigraphic units from top to base (Fig. 3 and 4):

Figure 3: Wannbach site 1. Construction pit of house number 71. Blue meter stick 1.20 m. Note the irregular top line (unconformity) of the gravel bed (penultimate glacial). Its red brown topping flood loam and soil (Btb3) is thicker preserved only in some hollows in the top of the gravel (last interglacial complex). A following thick layer of loess loam (Weichselian) is topped by the fossil early Holocene soil (Btb2) and followed by a grey colluvial humic sequence that embraces an ABtb1 horizon. Photo: W. SCHIRMER 14.05.2007.



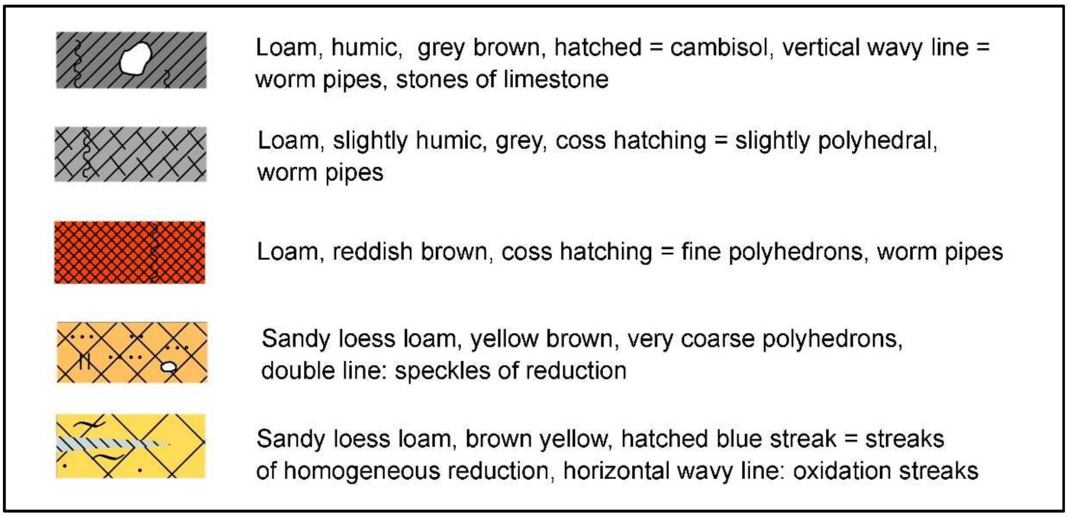


Figure 4: Wannbach section 1. Asterisks indicate positions of OSL sampling (For their ages see Fig. 6). Pedological symbols after FAO (2006).

1.10 humic colluvium
——————————
sub-recent luvisol
2.05 m loess
—————————-
fossil luvisol
75 basal river terrace.

Section Wannbach 1 in details:

Cambisol on humic colluvium:
Ap 15 cm Loam, fine sandy, silty, dark brown grey, humic, non-carbonaceous.
ABw 30 cm Loam, fine sandy, silty, grey brown, humic, non-carbonaceous, mixed by bioturbation, sub-polyhedral peds, scanty Upper Jurassic limestone fragments
———— erosional unconformity
Fossil luvisol-cambisol on humic colluvium:
ABtb1 65 cm Loam, fine sandy, silty, grey, slightly humic, non-carbonaceous, mixed by bioturbation, slightly polyhedral peds with dark brown clay coatings, worm pipes.
———— erosional unconformity
Fossil luvisol on loess:
Btb2 30 cm Loam, fine sandy, silty, reddish brown, few stones of fine grained sandstone, non-carbonaceous, fine polyhedral peds with strong red brown clay coatings.
Bgt 70 Loam, fine sandy, silty, yellow brown, large polyhedral peds with red brown clay coatings. Towards the bottom streaks of fine sand and few stones of fine grained sandstone. Spots of grey speckled gelic gleysol.
Bt 35 Loam, fine sandy, silty, brown yellow, non-carbonaceous, very large polyhedral peds with reddish brown clay coatings, few stones of fine grained sandstone.
Bgt 70 Loam as above, with grey bands and streaks of gelic gleysol.
———— erosional unconformity
Fossil luvisol on floodplain loam:
Btb3 20 cm Loam, clayey, dark red brown (Fig. 5), non-carbonaceous, subpolyhedral peds with strong red brown clay coatings, streaks of dark brown clayey plasma and brown grey humic clayey plasma, fragments of fine grained sandstone, of limonite and limestone and chert, rare quartz grains up to 2 mm in diameter.
Bt 55 Block gravel of limestone, sandstone, limonite and chert within a clayey non-carbonaceous matrix.

Figure 5. Wannbach section. Basal channel deposit with strongly weathered chalky limestone pebbles, overlain by a pocket of floodplain loam. This loam exhibits polyedric structure with shiny red clay coatings of the Btb3 horizon of the 3rd fossil luvisol. Aside the pocket the loam contains white remnants of strongly dissolved limestone pebbles. Width of the photo: 30 cm. Photo: W. SCHIRMER 14.05.2007.

Section Wannbach 2: Owing to loss of the first sampling of the complete section for analysis of the loess, later handdrilling could reach loess samples from 310,40 to 309,86 m a.s.l. (section Wannbach 2 tightly behind the locality of Wannbach 1) (Fig. 1 and 6).

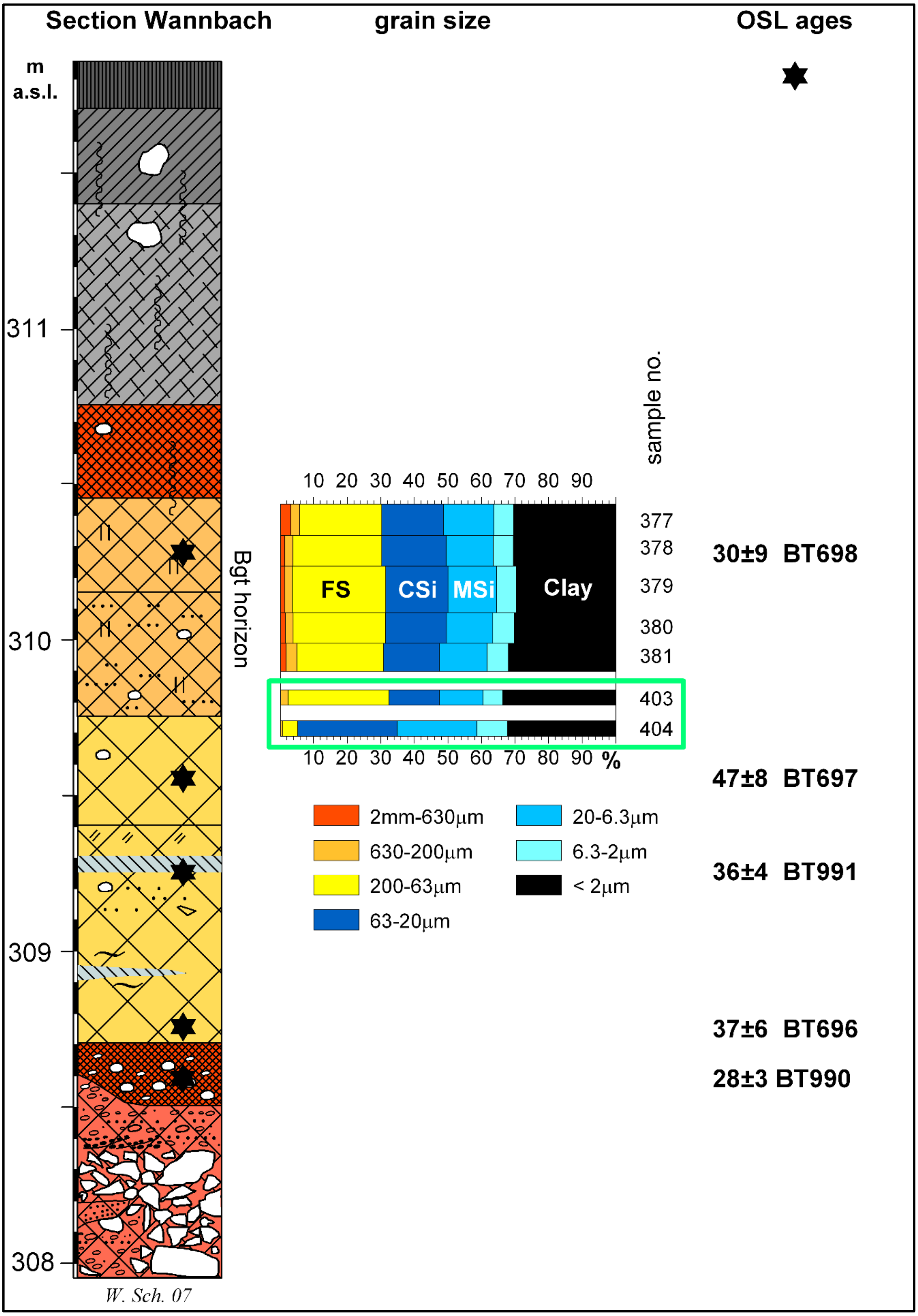


Figure 6. Wannbach section 1+2. With grain size analysis of the Bgt horizon and for comparison (within the green frame) two samples both of the Wannbach 3 construction pit (sample no. 403) and of Hagenbach (no. 404). Asteriks indicate positions of OSL sampling. OSL results in the right column.

3 Material and methods

3.1 Grainsize analysis

For grain size analyses, the classical pipette and sieve procedures after KÖHN was applied (ISO 11277). Five sediment samples (Alb 377-381) from section Wannbach 2, and two samples (Alb 403-404) from the surrounding area were added for comparison reason (green frame in Fig. 6). One of the latter samples (No. 403) was taken at a construction pit at 1.65 m depth next to the Wannbach 1 section (Wannbach 3 in Fig. 1), and the other sample (No. 404) was taken ca. 1.5 km west of Wannbach, from a modern road cut at Hagenbach from about the same depth (Fig. 1).

3.2 OSL dating

Five sediment samples from the Wannbach 1 (BT 696, BT 697, BT 698, BT 990, BT 991) section were taken for OSL dating (Fig. 6). The quartz coarse-grained fraction (90–200 m) of the sediments was used for OSL analyses, following the sample preparation procedure described by e. g. FUCHS et al. (2007). Luminescence measurements were carried out using a Risø Reader TL/OSL-DA-15 (BØTTER-JENSEN, 1997) equipped with blue LEDs (470 ± 30 nm) for stimulation, a Thorn-EMI 9235QA photomultiplier combined with one 7.5 mm U-340 Hoya filter (transmission 290–370 nm) for detection, and a 90Y/90Sr-source (9.2 ± 0.4 Gy/min) for artificial irradiation. The equivalent dose (D_e) was determined by applying a single aliquot regenerative (SAR) dose protocol (MURRAY & WINTLE, 2000).
The dose rates for OSL age calculation were determined by low-level γ -spectrometry, using the conversion factors of ADAMIEC & AITKEN (1998). The cosmic-ray dose rates were calculated after PRESCOTT & HUTTON (1994).

4 Grainsize of the loess

The difference between the Wannbach samples (No. Alb 377–381 and 403) and the Hagenbach sample (No. 404) is, that the Hagenbach sample was deposited at the leeward slope of the Trubach valley, those of Wannbach 1–3 at the luv or windward slope of this valley, applied to westerly winds during the Late Pleistocene.
The Wannbach 2 samples (no. 377–381) present loess rather rich in sand (30–32%), on average 31%. Thus, the deposit is called sandy loess. The same applies to the Wannbach 3 sample (no. 403). The question is whether this sand proportion is an ingredient of the primary dust input or an additional local ingredient.
The Hagenbach sample (no. 404) supports the latter version. It has a sand proportion of 5% only. All Wannbach samples lie at the slope toe of the Jurassic escarpment. Within this escarpment occurs the roughly 50 m thick Eisensandstein Formation, a fine-grained sandstone with thin iron ore seams of Middle Jurassic age. Obviously, this sandstone supplied fine sand to the Wannbach loess whether by local sand deflation or by solifluidal input, or by both actions.
Besides, the grain size distribution of all samples shows the conspicuous property of somewhat low coarse silt proportion compared with normal loess. However, this turns out to be an exception for this Franconian area as demonstrated by RÖSNER (1990: 205) in detail.

Herein, the proportion of middle silt to coarse silt is slightly increasing from west to east from values around 60% to values around 80% like they occur in Wannbach. RÖSNER attributes this phenomenon in first line to the host rock of an area that is in eastern Franconia predominantly built of clay and sand of Triassic and Jurassic age.

5 Luminescence dating of the loess

5.1 Lithostratigraphical prerequisites

The lithostratigraphical prerequesites are the basal river terrace capped by a luvisol and the loess layer overlying the luvisol capped by the recent soil. The base of the loess section is a river terrace of the small stream Thoosbach accompanied by landslide material, which is exposed at the base of section Wannbach 1 (Fig. 4). The terrace ends with a strong luvisol complex that shows mature clay illuviation (Bt horizon). As the Bt horizon underlies a loess sequence it must date at least to the last interglacial. As its upper boundary lies 2.3 m above the river level, the terrace should date at least to the penultimate glaciation (late MIS 6).
A river terrace with similar valley position to Wannbach is the Nassanger Terrace of the River Main that also is topped by a fossil luvisol.

This basal Wannbach luvisol above the river terrace (Btb3 in Figs. 3 and 4) exhibits at least two clay illuviation suites, which is normal for the solcomplex of the last interglacial (SCHIRMER 2016b).

The loess stack above does not present any typical indicator horizon to decide whether it would belong to a special part of the last glacial loess. The frequency of distinct grey gelic gleysols might indicate the earlier part of the last glacial loess as referred by BRUNNACKER (1957) and SCHIRMER (2016b).

5.2 The Wannbach luminescence data

The basal datum of 28 ka is too young for an interglacial luvisol. If the four data within the loess loam above would likewise tend to be too young, the whole loess stack would date to the earlier part of the last glacial loess. In case the loess data are reliable, likewise the Wannbach loess would not represent the younger part of the last glacial loess.

6 Results

Looking at the geological maps of the Northern Franconian Alb (1:25,000), no loess deposits are indicated within the valleys. However, this study shows, that at least the foot slope positions are covered by a veneer of loess deposits. The loess below the escarpment of the Middle Jurassic sandstone (Eisensandstein) has a high content of fine sand (ca. 30%), which decreases with distance to the escarpment (ca. 5%). The overall silt content of the loess from Wannbach is due to its host rocks poor in coarse silt. Concerning the age of the loess from the Wannbach section, the litho- and pedostratigraphic information indicate an early Weichselian age, with OSL ages older than 30 ka.

7 Conclusions

The bulk of loesses in Franconia is younger Weichselian loess (RÖSNER 1990). At the Wannbach locality, preservation of early Weichselian loess and lack of younger Weichselian loess at the slope toes means that the younger loesses were eroded, washed off. Concerning the missing coarse silt prevalence within this loess, this should be typical for clayey–sandy areas in the hinterland of the great river plains, here the Rhine and the Danube rivers.

8 Acknowledgements

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To all of them our best thanks.

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