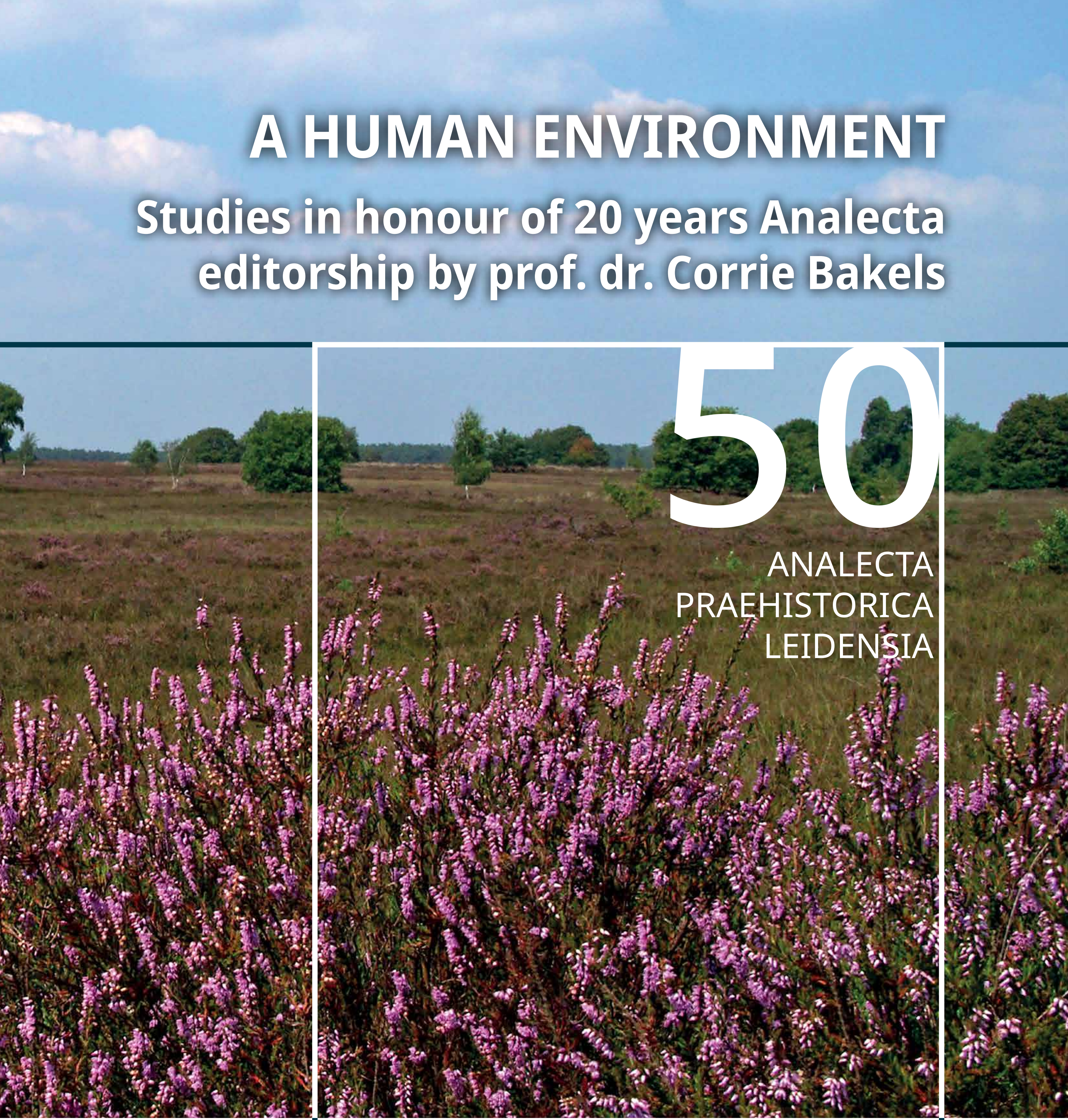
A HUMAN ENVIRONMENT

Studies in honour of 20 years Analecta editorship by prof. dr. Corrie Bakels



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ANALECTA PRAEHISTORICA LEIDENSIA

edited by

VICTOR KLINKENBERG, ROOS VAN OOSTEN AND CAROL VAN DRIEL-MURRAY

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sidestone press

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Contents

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Landscape dynamics near the late Middle Palaeolithic and Early Upper Palaeolithic cave site of Les Cottés (France)

Joanne Mol, Lars den Boef and Marie Soressi

The cave site Les Cottés (Central France), famous for its occupation by both Neanderthal and anatomically modern humans and its Les Cottés Interstadial, is located in the steep side of the incised Gartempe River valley at about 5.5 m above the present floodplain. So far, little is known about the landscape at the time of occupation, about 48-37 ka. The erosional nature of this type of fluvial landscape complicates such a research – when no traces are left, it is difficult to assess how such a landscape looked like.

We were able to study the present floodplain through a series of hand cores. A coring transect stretching from the front of the cave towards the present river course showed that the flood deposits covered an older terrace remnant and an abandoned channel, just in front of the cave. The channel fill of this palaeochannel contained a thin layer of peat at the base that has been studied by means of pollen analysis. It pointed to an open landscape, dominated by Pinus, Betula and Artemisia. Two additional radiocarbon dates dated the channel fill to 11,286-11,094 yrs cal BC and 11,140-10,849 yrs cal BC, respectively, which fits with the results of the pollen analysis. It showed that the channel became inactive in the Weichselian Lateglacial, leading to a minimum age of Weichselian Pleniglacial for the underlying terrace, which postdates the time of occupation of the cave site.

Another important discovery was the presence of a terrace remnant, covered by flood and slope deposits, in between the site and the underlying floodplain. This terrace could not be dated, but it is likely that this terrace already existed as an inactive terrace at the time of occupation, since the height of this terrace is only 5 m lower than the cave site, in which no flood deposits have been found. We therefore conclude that the terrace located in the subsurface of the present floodplain probably represents the active river at the time of occupation, when the site was located 5 m above a small plateau that was still flooded regularly, and 7.5 m above the active river.

The study has shown that the Gartempe River valley underwent considerable changes during the Last Glacial. The small terrace remnant in front of the cave site is part of a former floodplain that was eroded. This erosion likely occurred during the time of occupation, as well, and shows that the river was much more active then than it is nowadays.

Keywords: Late Pleistocene, Weichselian Lateglacial, palaeoenvironment, fluvial dynamics, terrace sequence, France

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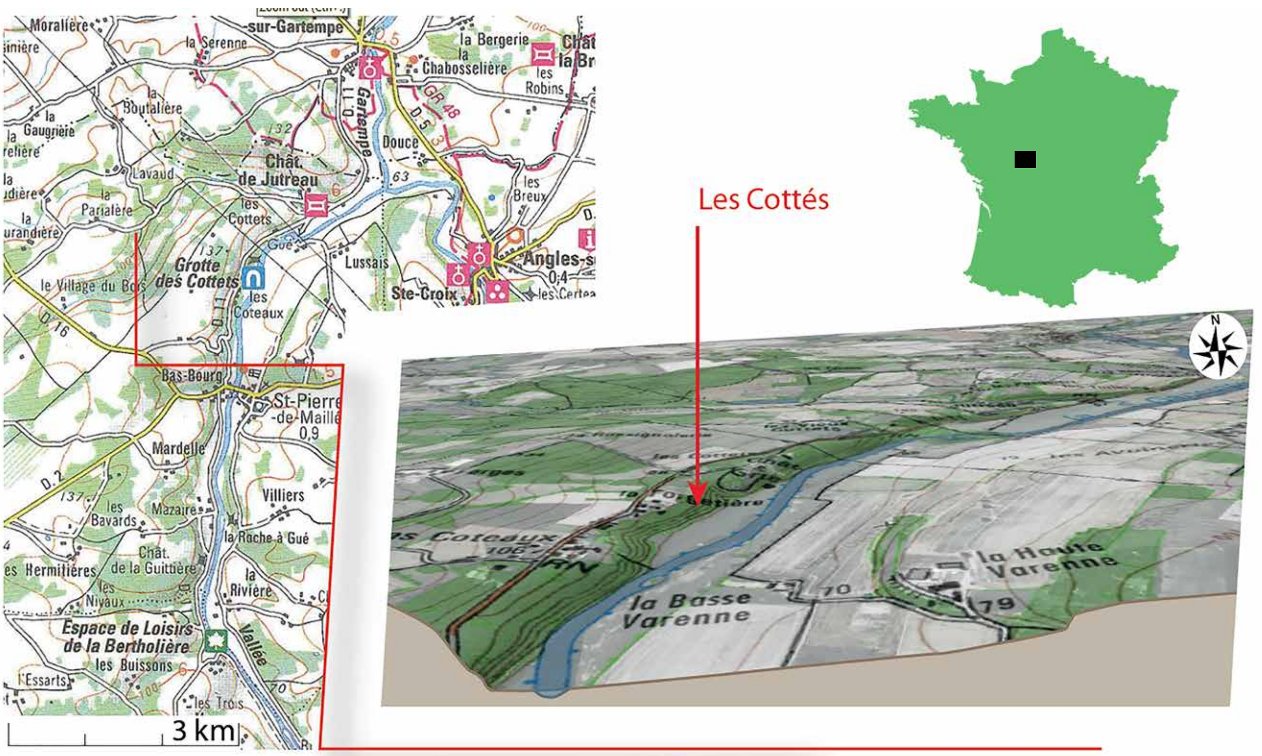

Figure 1: Location of Les Cottés and profile of the valley. Data derived from www.geoportail.gouv.fr.

1. Introduction

The French cave site of Les Cottés (Vienne) is a one of the rare recently excavated sites that has been occupied by both Neanderthals and early anatomically modern humans (Soressi *et al.* 2010). It is the location where the Les Cottés Interstadial, one of the many climatic events happening during Marine Isotope Stage (MIS) 3, defined based on pollen analysis (Bastin *et al.* 1976). Its archaeological deposits were originally discovered at the end of the nineteenth century. The archaeological sequence is 1.5-4 m thick and comprises five main archaeological layers attributed to the final Middle Paleolithic and the Early Upper Paleolithic (Roussel and Soressi 2013). Radiometric dating has shown the archaeological sequence to be at least 48-37,000 years old (Jacobs *et al.* 2016; Talamo *et al.* 2012).

The site is located on a steep slope of the incised valley of the Gartempe River (figure 1), a tributary of the larger Creuse River. The site location choice is clearly connected to the presence of the river; it has been in use as a resource area for quartz, as shown by the presence of fluvial gravel in the finds layers. The site is located at 5 m above the present river valley floor. The present geomorphology shows an extensive floodplain in front of the site that is still flooded regularly. Older terraces appear to be absent. So far, it is unclear how the landscape looked like during the time of occupation. In an erosional landscape, as is the case at Les Cottés, it is difficult to obtain this type of data, because much information is missing. Some information may be inferred from the deposits that have been preserved.

In this study, we intend to shed some light on the chronology of the landscape dynamics around this important site. The research concentrated on the sedimentary composition of the floodplain, since a similar campaign in the Vézère River valley revealed the presence of a series of terraces covered by a thick layer of overbank deposits. The top of the fluvial deposits that formed the terraces were sandy in nature, which allowed luminescence dating. It pointed to the existence of two different terrace levels that were both dated to the Last Glacial. It showed that a similar erosional landscape had preserved traces that allowed us to extract palaeoenvironmental data (Mol *et al.* 2004; Roebroeks *et al.* 2009).

In 2015, some trial cores in the floodplain of the Gartempe indicated that it was possible to sample the fluvial deposits up to several meters: the top consisted of loams, with some occasional fluvial gravel (rounded) and angular limestone fragments. This paper shows the results of a coring campaign in the Gartempe River valley and additional pollen analysis and dating of a peat layer that was recovered during the fieldwork. The initial results have been described earlier in the excavation report of Les Cottés (Roussel *et al.* 2017) and in an (unpublished) bachelor thesis (Den Boef 2017). In this research, we have combined the results and present two additional radiocarbon dates.

During the fieldwork, a small platform of about 10 m wide was discovered between the floodplain and the cave site. It was covered by excavation and slope debris from earlier excavations and was fully overgrown by trees. This plateau had a natural origin, since it was clearly separated from the present floodplain by an escarpment with a height difference of almost 2 m, and its age is therefore older that the present floodplain. It was believed to be a terrace remnant of an earlier fluvial stage that may be related to the time of occupation, but this assumption needed evidence.

2. Sedimentary sequence of the river valley

2.1 Methods

Geomorphologically, the cave site Les Cottés is located in the steep terrace scarp of the entrenched Gartempe River valley. The river has incised into a limestone plateau and created a narrow river valley in which clear terraces appear to be absent. The present river flows in an extensive floodplain that is still flooded regularly. The top of this floodplain is located at a height of c. 5 m below the cave site. It is currently in use as pastureland, allowing us to easily sample the fluvial deposits.

In July 2016, a geological coring transect was laid out from just below the cave towards the present river channel (figure 2). The cores were made using a 7 cm Edelman hand auger and a 3 cm gouge for the fine-grained deposits below the water table. A core was abandoned when the gouge hit impenetrable coarse gravel and rock fragments. The top of these coarser units could be usually be sampled, facilitating the interpretation of these units. The transect is shown in Figure 3. The cave site is shown schematically, allowing us to compare its height to the height of the deposits studied.

2.2 Results: The lithostratigraphic units

The cores were made every 10 m, and their locations are shown by arrows in the transect (figure 3). The maximum depth reached was almost 4 m below the surface (core 14). In most cases, the transect shows the maximum depth reached. Only the core nearest to the cave entrance, number 12, did not sample the entire unit. The lower boundary has been extrapolated, which is shown by a dotted line. This extrapolation will be discussed below in more detail below.

The cave site is shown schematically to show the different elevation levels identified in relation to the site. The deposits have been subdivided into nine lithostratigraphic units, of which the interpretations are shown in the legend.

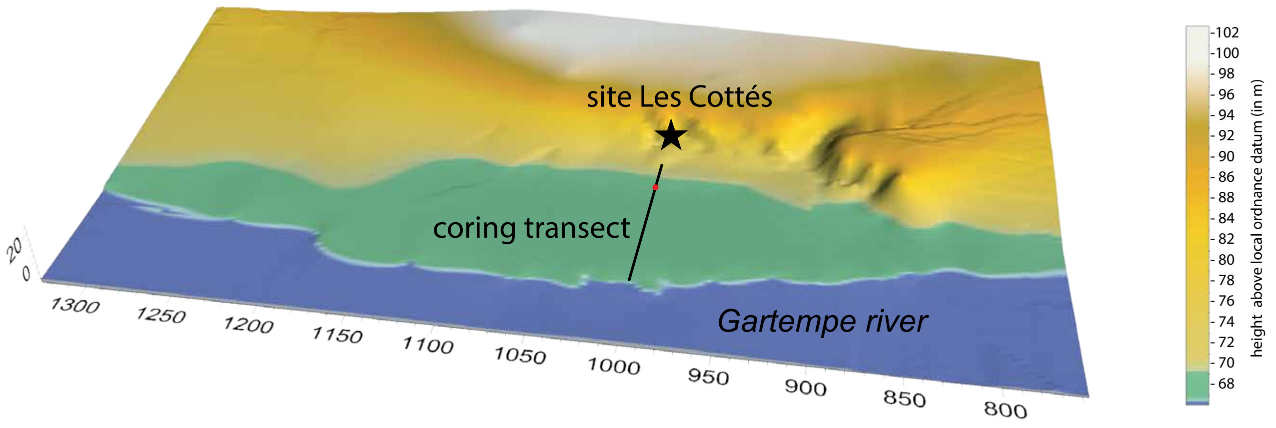

Figure 2: Location of the transect in relation to the river and the site, shown on a shaded relief map. The coordinates refer to the local coordinates used in the excavation.

The majority of the cores sampled the deposits in the present floodplain (n = 9). Ten different litho-stratigraphic units have been distinguished and are described below in table 1 from old to young.

Unit 1 represents the bedrock of the plateau into which the river incised. It consists of white (Jurassic) limestone, of which small (1 cm) to sometimes very large, angular fragments (5 cm) were frequently

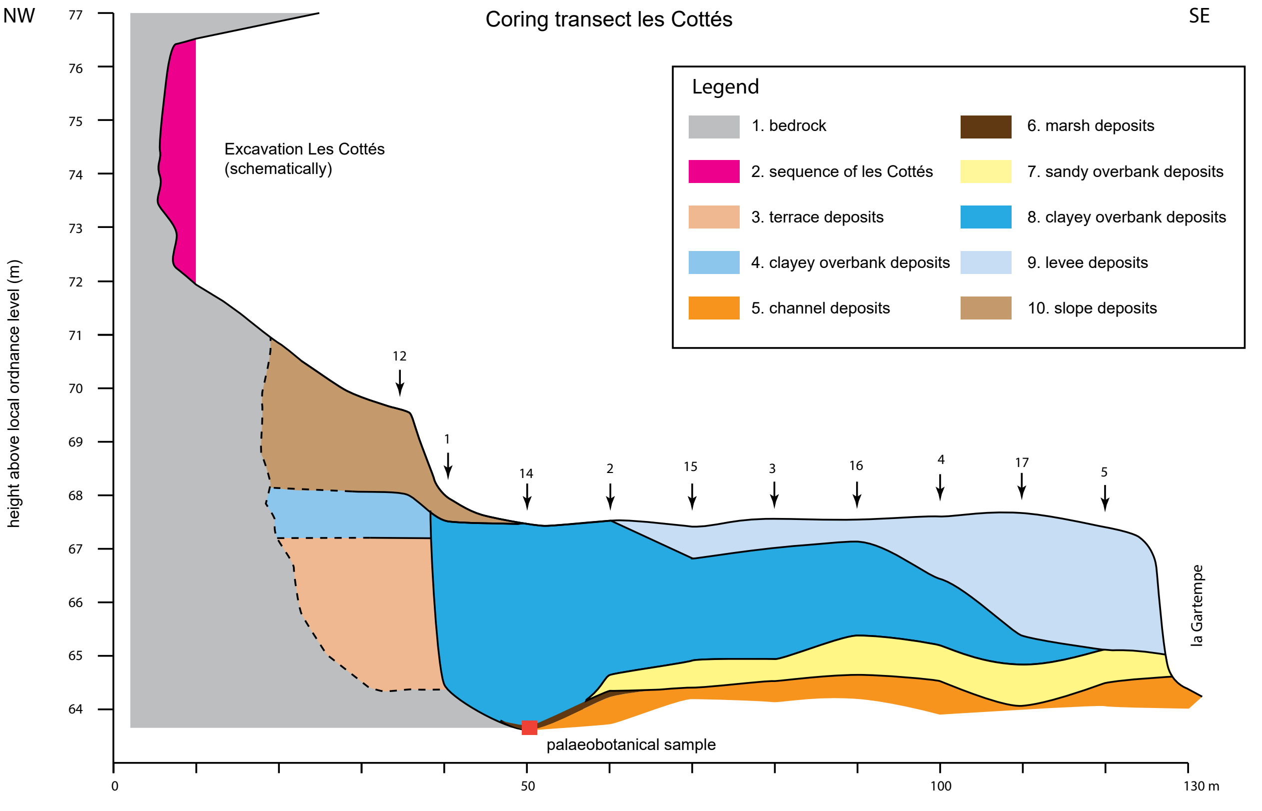

Figure 3: The coring transect, in front of the Palaeolithic site Les Cottès.

unit	composition	interpretation
1	Limestone	Jurassic bedrock
2	Angular fragments of limestone, containing bone and flint	Scree slope deposits, archaeological levels
3	Gravelly coarse sand, mainly containing quartz, slightly clayey	Fluvial channel deposits
4	Very firm clay loam	Overbank deposits
5	Slightly silty, slightly gravelly sand with gravel up to 2 cm	Fluvial channel deposits
6	Clayey peat	Marsh
7	Coarse- to fine-grained sand, alternating with clay layers and organic detritus	Sandy overbank deposits
8	Humic clay loam, containing angular limestone fragments and rounded quartz pebbles up to 2 cm	Clayey overbank deposits
9	Sandy loam to silty sand with some local clayey intervals	Levee deposits
10	Very firm, humic silty clay with angular limestone fragments up to several dm	Slope deposits: colluvium

Table 1: Descriptions of the lithostratigraphic units identified in the transect.

encountered in the cores. In core 1, we could not penetrate as deeply as the other cores, because of an obstruction, either a very large boulder of limestone, or perhaps the bedrock itself.

Unit 2 represents the archaeological sequence of Les Cottés, shown in the transect to allow us to compare the heights of the archaeological units with the units sampled in the cores. The excavated layers consist mainly of scree slope deposits; fluvial deposits have not been found in the excavations. This sequence is not described here, since it has already been intensively excavated and described by the team of Soressi (Soressi *et al*. 2010).

Units 3 and 4 were encountered in core 12 only. This core is located on the small platform in between the cave and the floodplain. These units represent the deposits that form the plateau.

Unit 3 is composed of gravelly coarse sand containing many quartz grains. It also contained some clay that is believed to have infiltrated from the overlying clayey layer (unit 4). The top of these deposits is located at an elevation of c. 67.2 m. The unit is interpreted as fluvial (channel) deposits, representing deposition in an active river channel. The presence of quartz sand at this height clearly proves that the small plateau is a terrace remnant and is older than the present floodplain. Sampling these deposits proved to be extremely difficult due to the vast amount of rocky slope fragments at the surface and the firmness of the overlying loam. Therefore, we were only able to sample this unit once.

In the transect, these units have been extrapolated to the valley side and to a much deeper depth than we have sampled, to illustrate our interpretation of the sedimentary sequence. We have sampled only 25 cm of these channel deposits, but they were indisputably fluvial in origin, as evidenced by the rounded quartz grains. The exaggerated thickness exemplifies the origin of the plateau, a terrace remnant, which is very important new evidence. The boundary with the underlying bedrock is based on data obtained in core 1, where we assumed that we reached the bedrock.

Unit 4 overlies the terrace remnant of unit 3. It consists of very firm clay loam that is interpreted as overbank deposit. It does not contain any lime, in contrast to the clay loam that was sampled on the floodplain. Given its height, this clay loam may still be young in age, but given its other characteristics, its firm appearance and lack of lime and limestone fragments, it clearly differs from the lower clay loam deposits (unit 8) located in the present floodplain. Therefore, it is believed that this deposit represents an older flooding phase. These loamy deposits have been sieved to look for any datable material, but regrettably, nothing was found. The clay loam was also sampled to check if it contained any pollen, but similarly, no pollen was preserved. Unit 4 is overlain by unit 10, which is described last.

The younger units have all been sampled in the floodplain. Unit 5 is the lowermost unit and composed of slightly silty gravelly sand containing gravel up to 2 cm. It is located below the water table, at a depth of about 3 m below the surface. It was usually not preserved in the gouge (or only a few quartz grains that were left), because of the high water table: all deposits that do not contain much loam (or clay) will not stay in the gouges that were used. Unit 5 is interpreted as channel deposits, representing the active river.

The relationship between these channel deposits and the channel deposits of unit 3 can be established by comparing the height of the deposits. The tops of both units are covered by loams, indicating that no erosion occurred: the tops of these units represent the maximum height of the channel deposits (point bar and lag deposits). The top of unit 5 is located at an elevation of c. 64.7 m, almost 2.5 m lower than unit 3. Based on this height difference, it can be concluded that these depositional events are separated by an incision phase, which resulted in the formation of a new floodplain with new channel deposits located at a lower elevation. Hence, it shows that unit 5 represents a younger fluvial phase: unit 5 is clearly younger than unit 3.

Another remarkable feature is the variation in height of the top of this unit. As shown in the transect, the top of the unit decreases in height towards the valley side; unit 5 is almost 1 m deeper in core 14 than in the other cores. It points to the presence of a natural depression in the landscape and is believed to represent a residual channel.

Unit 6 was encountered in cores 14 and 2, just near the terrace scarp, and is located directly on top of unit 5. It is composed of a maximally 10 cm thick layer of slightly clayey peat. The unit is located at the base of the residual channel, pointing to marshy, stagnant water conditions after the abandonment of the channel. The clay shows that the floodplain was still flooded irregularly, resulting in clay deposition in a vegetated, marshy depression.

Unit 7 overlies unit 5 in all cores (2-15-3-16-17-5), except for the part where the residual channel is located. It has a sandy character, similar to unit 5, but this sand shows more variety. It ranges from very coarse to fine-grained and is intercalated with clay layers and detritus. The presence of clay layers show that this deposit is unlikely to have been deposited within an active channel; therefore, the unit has been interpreted as sandy overbank deposits, probably related to the fluvial system that deposited unit 5.

Unit 8 is located on top of unit 6 and consists of slightly humic clay loam that often contains limestone fragments and (rounded) quartz pebbles. It has been interpreted as clayey overbank deposits that have formed the present floodplain.

Unit 9 overlies unit 8 locally and replaces it near the present river. It is composed of sandy loam to silty sand with some local clayey intervals. It has been interpreted as sandy overbank deposits, that, given the location, can be interpreted as levee deposits. Units 8 and 9 together have formed the present floodplain, of which the levee has developed next to the present channel course, and the finer-grained overbank deposits have silted up the more distal parts of the floodplain. Both units have gradually covered the underlying landscape during irregular flooding events.

The final unit is unit 10. It consists of very firm, humic silty clay that contains many angular limestone fragments in all sizes and does not contain rounded pebbles. This unit is located on a slope and overlies units 8 and 10 in the northwestern part of the transect (cores 12 and 1), covering both the plateau and the present floodplain near the scarp. It has been interpreted as slope deposits and likely formed as a result of slope processes, such as surface creep, that remains active today. Regrettably, it obscures much of any older terrace remnants. After several attempts, we could core through this unit and could show that the older platform in front of the site was covered by at least 160 cm of this rocky, firm clay. Its firmness and the presence of large clasts – sometimes too large to bypass using the hand auger – made sampling of the underlying deposits extremely difficult.

2.3 Fluvial development of the Gartempe

The present fluvial activity appears to be very low, with mainly overbank deposition during flooding events. During floods, sand is deposited on the levees near the present channel and clay loam further away. The coring campaign demonstrated the presence of terrace remnants consisting of older channel deposits located at two different levels. The deposits of the present floodplain overlie an older fluvial landscape comprised of floodplain deposits and associated channel deposits. These older deposits appear to reflect an older, more active, fluvial phase, of which a palaeochannel near the valley side represents its final phase.

Only one core proved the presence of a small terrace remnant at a higher level that is separated from present floodplain by an erosional scarp and is, therefore, older than the present floodplain. It is also older than the terrace underlying the present floodplain, since its top is located 2.5 m higher. These terrace levels reflect the level of deposition by the (active) channel; individual flooding events will likely have reached much higher levels.

The age of the deposits is difficult to establish without any chronological data. The present floodplain still experiences deposition and is therefore probably relatively young. The clayey overbank deposits on top of the highest terrace, though, may be older. These deposits have been covered by slope deposits, and their characteristics differ from the flood deposits on the present floodplain. They may very well be deposited by the river system that now forms the lower, buried terrace, similar to the more sandy unit 7, but that relationship could not be established. Perhaps luminescence dating on the fluvial sandy deposits could help to answer this question in a future campaign.

The basal infill of the residual channel near the terrace scarp is peat and allowed for palynological investigation and radiocarbon dating. These enabled us to put the relative chronology into a chronostratigraphic framework. Their results are described below.

3. Environmental evidence

The coring campaign showed the existence of sediments that represented older phases of fluvial activity. Acquisition of this information was one of the key aims of the field campaign. For correlation with the site, however, we also needed chronological information. The discovery of a fossil channel in front of the site, which contained peat at its base, was therefore very useful. The deepest part of the channel fill was located at 385 cm below the surface (63.5 masl) and contained a clayey peat layer of 10 cm thick at its base (unit 6). This peat was sampled for pollen analysis and radiocarbon dating, allowing us to assess the environment at the time of the peat formation, and to provide a biostratigraphic correlation. Three samples were taken for pollen analysis: at the base, in the middle and at the top.

3.1 Preparation of the pollen samples

The sample treatment followed standard methods (Moore and Webb 1978, 23). *Lycopodium* pollen grains were added to samples of 2 cm^3, mainly to test for

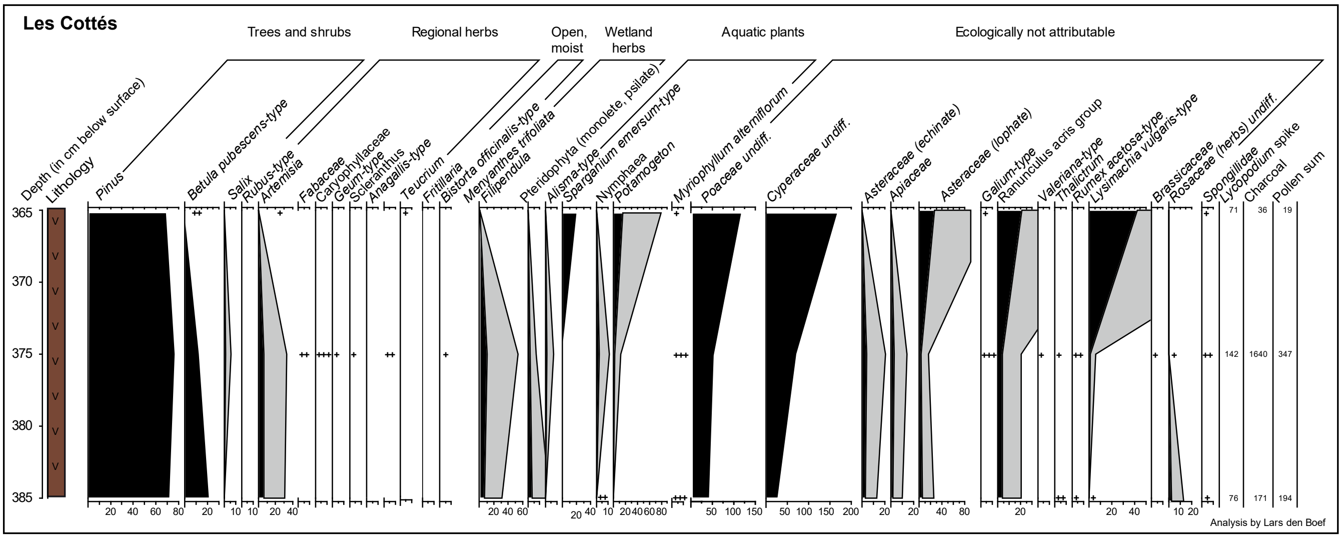

Figure 4: Percentage diagram of the channel fill of the lower terrace in front of Les Cottés (core 14, 365-385 cm below surface, 63.5-63.3 m above sea level. The percentages are based on a terrestrial pollen sum only including the trees, shrubs and regional herbs. The name of the taxa are based on Beug (2004). Percentages exaggerated 5x are shown in grey. Rare taxa are shown in absolute numbers, indicated with +. The basal part dated to 11,100 ± 50 yrs BP (GrM 12581)) (11,140-10,849 yrs cal BC)., the top dated to 11,260 ± 65 years BP (GrM 12700) (11,286-11,094 yrs cal BC). The calibrations were performed in Oxcal, version 4.3.2, using IntCal 13. (Bronck Ramsey 2017; Reimer *et al.* 2013).

irregularities during the sample processing, but also to allow the construction of a concentration diagram. The samples were treated with potassium hydroxide (KOH) to remove the humic acids. Next, the KOH was carefully washed out with alcohol, and in the following step, the pollen grains were separated from the bulk by bromoform ($CHBr_3$) and alcohol solution with a specific gravity of 2.0. In the last step, the cellulose was removed from the residue by means of acetolysis, and the final residue was mounted on microscope slides in glycerol. The resulting samples contained pollen grains and some other microfossils, such as non-pollen palynomorphs (NPP).

3.2 Results of the pollen analysis

Firstly, a concentration diagram was created, which showed a significant decrease in the amount of pollen for all taxa in the top sample (Den Boef 2017). The fact that this decrease occurred in all taxa suggests that it was not related to ecological changes, but was likely caused by the landscape dynamics.

The peat layer was overlain by humic clay that contained pieces of limestone and gravel, interpreted as a floodplain deposit (unit 8). Generally, these sediments tend to be deposited irregularly, allowing time for oxidation of the top of the peat. Another indication for this degradation is that little datable material was found at the top of the layer.

A percentage diagram includes the different taxa that have been identified in the samples (figure 4). The peat contained taxa from both aquatic and dry environments. This corresponds to the location of the sample; the aquatic taxa reflect the local environment, a small basin in a residual channel (cut-off) on a floodplain, whereas the dry taxa can be traced back to the high plateau, located directly above the sample location.

The regional vegetation was dominated by pine (*Pinus*) and low percentages of birch (*Betula*). Additionally, the assemblage was characterized by mugwort (*Artemisia*), sedges (Cyperaceae) and different taxa of the carnation family (Caryophyllaceae), such as the knawel (*Scleranthus*), which together point to an open landscape. The local plants, such as pondweed (*Potamogeton)* and the white water-lily (*Nymphea*), yellow water-lily (*Nuphar*), reflect the open water conditions that occurred when the residual channel was no longer active. At the edge of this water body, meadow conditions existed, shown by the presence of bogbean (*Menyanthes trifoliata)* and water plantains (*Alisma*), and likely also sedges, although these may also reflect the regional signal.

3.3 Dating the channel fill

Chronologically, this assemblage points to the onset of a warm stage and hence may point to a Late Glacial or Preboreal age (Bakels 1995; Barbier and Visset 2003). Two radiocarbon dates obtained from the base and top of the peat layer, respectively, allowed a more accurate age estimation. The samples dated were seeds from a terrestrial source. The top sample contained only a very small amount of datable material, but the Groningen Center for Isotope Research was able to date the sample by the "small sample batch procedure" (de Rooij *et al.* 2010). Table 2 shows the dating results of both samples. Their dates are consistent and point to a reliable age estimation: the lower sample (GrM 12700) was dated to 11,260 ± 65 yrs BP (11,286-11,094 yrs cal BC), whereas the upper sample was dated to 11,100 ± 50 yrs BP (GrM 12581) (11,140-10,849 yrs cal BC). The calibrations were performed in Oxcal, version 4.3.2, using IntCal 13. (Bronck Ramsey 2017; Reimer *et al.* 2013) and have a standard deviation of 2σ (95.4% confidence). The calibrated dates point to a Late Glacial age, which is in accordance with the results of the pollen analysis that indicate an open environment at the time of the peat formation.

In a sequence in the Aisne River valley (Northern France), a similar assemblage was found, dating to the Younger Dryas: *Pinus* and *Betula* with *Cyperaceae* and P*oaceae,* pointing to open but dry (steppe) conditions (Boulen 2000). Pollen and Coleoptera data from Aubrac, a plateau in the central part of France, showed a dry and cold environment around 11,000 yrs cal BP. The vegetation was characterized by steppic herbs (*Artemisia*, *Helianthemum,* Chenopodiaceae, Caryophyllaceae, Poaceae), but low percentages of *Pinus* and *Betula* compared to our results (Ponel *et al.* 2016), probably related to its geomorphological setting on a high plateau.

4. Sedimentary history of the Gartempe: chronology

The existence of river deposits associated to the time of occupation of Les Cottés could not be established with certainty. They may have been eroded completely during later stages. The fieldwork proved the existence of two levels of channel deposits, pointing to two terrace remnants, of which the age is difficult to assess. These channel deposits reflect active deposition inside a river channel. Floodplain deposits, which have been sampled as well, are even more difficult to date and relate to an active river channel. They are deposited during floods that may reach considerable heights, and may even cover higher levels, such as older terraces, when the flooding is exceptionally large. Hence, the elevation of channel deposits is a better reflection of the activity of a river than the irregular deposition during flooding events.

The Late Glacial age of the channel fill of the lowest (and therefore youngest) terrace allows us to shed some light on the chronology of the terraces: it shows that all deposits underlying this residual channel have a *terminus ante quem* age older than c. 11,000 yrs BP and hence undisputedly date to the Last Glacial. These are all channel deposits, and this age shows that the present floodplain covers an older terrace that reaches an elevation of c. 64.5 m.

The small terrace remnant located in front of the cave site could not be dated in a direct way. It is an older terrace than the terrace covered by the floodplain. Its formation was preceded and followed by erosional phases, as shown by the presence of the escarpments above the plateau and towards the present floodplain. The elevation of this terrace is 67 m, about 2.5 m higher than the top of the younger terrace.

Comparison to the age of the archaeological sequence of Les Cottés helps us to refine this relative chronology. The base of these deposits is located at an elevation of c. 72 m, which is only 5 m higher than the top of the channel deposits of the oldest terrace. Given that no fluvial deposits have been found in the archaeological sequence, it implies that from the time of occupation, dated to 46-35 ka cal BP, all flooding events only occurred up to elevations lower than 72 m.

The oldest terrace found is only 5 m lower than the cave site, a difference that could easily be bridged

Sample name	Dated material	GrM code	$F^{14}C$ ± 1σ	^{14}C Age ± 1σ (yrs BP)	%C	$\delta^{13}C$ ± 1σ ($^0/_{00}$)
CTS'17 – 18 TOP	charred seeds	12700	0.2511 ± 0.0021	11,100 ± 65	57.3	-27.58 ± 0.05
CTS'17 – 18 BOTTOM	charred seeds	12581	0.2461 ± 0.0007	11,260 ± 50	58.7	-27.93 ± 0.12

Table 2: Results of the AMS dating of the top and bottom of the peat layer in the residual channel fill in core 2016-14 *(CTS'17-18 TOP was analysed in a "small sample batch" with AMS).*

during a large flooding event in a confined river valley such as the Gartempe. Therefore, it is likely that this small terrace remnant was already inactive during the occupation of Les Cottés, although deposition of loam during flood events likely still occurred on top of the terrace, as shown by the presence of unit 4. This would imply that the underlying terrace probably represents the active river channel, from which overbank loam was occasionally deposited on higher levels, including the 2.5 m higher terrace, but did not reach the 7.5 m higher cave site. It should be noted that this active river was responsible for the erosion of almost all deposits that formed the upper terrace, of which only a small part in front of the cave is presently preserved. It shows that the Gartempe River was much more active during the Last Glacial than it is nowadays.

5. Conclusions

The field survey has resulted in more insights into the fluvial dynamics of the Gartempe River during the Last Glacial. Initially, it appeared that the river eroded any older deposits, but we could identify two terrace levels, of which the upper one already existed, and the lower one possibly reflects the active floodplain at the time of occupation of the cave.

A residual channel fill in the lowest terrace, located directly in front of the excavation, could be dated to the Younger Dryas, the last part of the Last Glacial. The Late Glacial age of the channel fill allowed us to put the sedimentary sequence in a chronological framework: the lowest terrace, covered by the present floodplain, dates to the Last Glacial. It may have been active up to the Alleröd interstadial. The upper terrace most likely dates to before the occupation of the cave, since the small elevation difference between this terrace and the cave site would have resulted in occasional flooding and hence loam deposition inside the cave, and this is not the case.

Therefore, during the time of occupation the site was likely located 5 m above a former terrace that was occasionally flooded. Only a small remnant of this terrace has been preserved; the largest part has been eroded by the Gartempe River, of which its floodplain was located at 7.5 m below the cave site. This is much lower than today and allowed the humans to use the valley as a resource for water and materials at safe distance from any floods. Direct dating of the sandy channel deposits in both terrace levels using OSL would improve the understanding of the proximity of the water relative to the cave during the cave occupation.

Additionally, pollen analysis of a residual channel of the lowest terrace pointed to an open landscape during the Younger Dryas, with *Pinus, Artemisia,* Poaceae and low percentages of *Betula*. The dry taxa were initially attributed to the geomorphological setting, below a plateau, but since pollen diagrams of other regions in France also contain these dry taxa, they may also reflect a regional signal.

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