Time-history of the gravel sheet in Ardennian rivers over the last 100,000 years

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Introduction

It is generally held that, in north-western Europe, the main part of the gravel sheets under river beds were deposited during the Weichselian period in a periglacial environment. However, other parameters such as propagation of knickpoints in fluvial networks may also influence incision or aggradation. Yet, only few studies have dated the periods of formation of the gravel sheets and have described their properties.

The first aim of this research was to determine the thickness of the gravel sheets still remaining under the river beds and to estimate the potential incision of these rivers before reaching the bedrock. Then we tried to answer a number of other questions: (a) When did these thick gravel deposits fill the valley bottom? (b) When were the lowest terraces abandoned? (c) When did the rivers incise the bedrock? (d) What is the morphology of the bedrock under the gravel layer?

Methodology

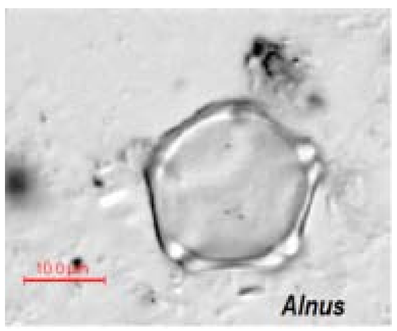
Numerous boreholes were made by percussion drilling in different floodplains of the Ardenne Massif and core samples were taken, down to the bedrock. Data from the Geological Survey of Belgium was also collected.

Coring machine Geoprobe ®

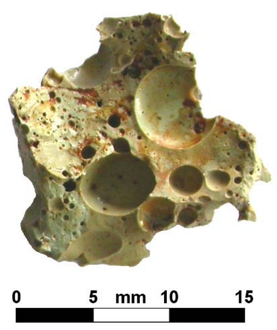
Pneumatic hammer used as a hand penetrometer to locate the contact gravel sheet / bedrock

Contact between rounded gravel and weathered bedrock at a depth of 500 cm in a core sample taken in the gravel sheet of the Ourthe River in Houffalize

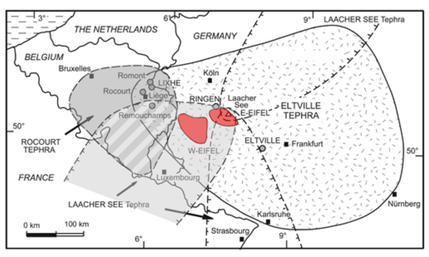
Different cryptotephras from the Late Pleistocene were used as stratigraphic markers to date the relative periods of terrace formation and to reconstruct the past evolution of the gravel sheets. Pollen and metallurgic slag were also analysed to date the periods of bed level evolution (Denis *et al.*, 2013).



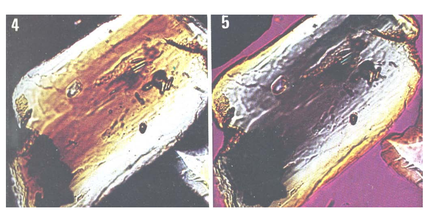
Pollen



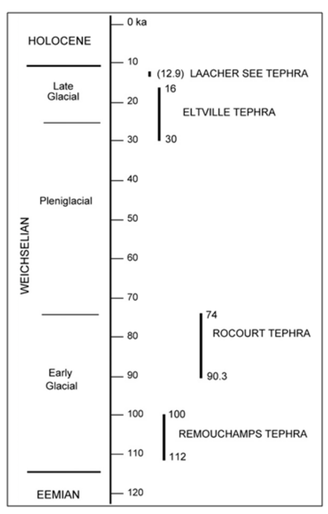
Iron Slag



Lobes of the Eltville, Rocourt and Laacher See Tephra (modified from Pouclet and Juvigné, 2009)



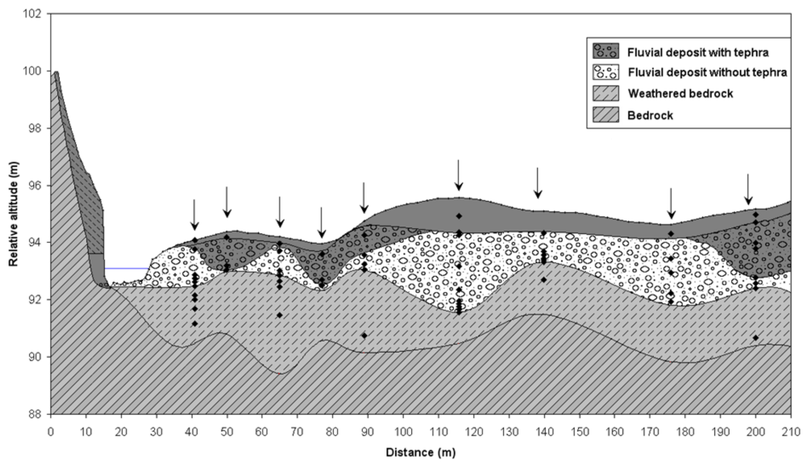
Volcanic ash: Amphibole under a polarised microscope (Parfenoff et al., 1970)



Chronostratigraphic distribution of the late Quaternary tephra layers in Belgium (modified from Pouclet et al., 2008)

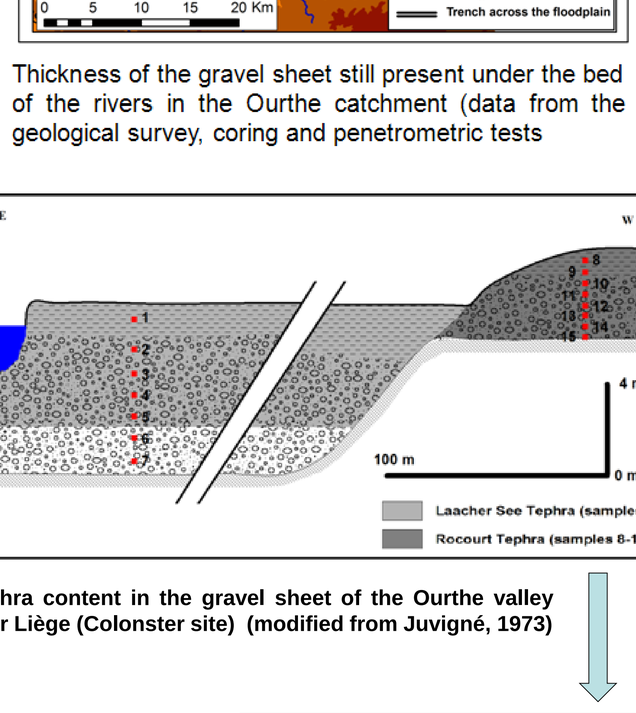
Results

-In the Ardennian massif, the thickness of the gravel sheet still present under the river beds is very variable (from 10 m in the downstream part of the Ourthe River to less than 1 m in the upper catchments). This figure represent the lateral variation of the gravel sheet thickness of the Aisne River (Roche-à-Frêne site). Under the gravel sheet, the bedrock (Emsian shale) is weathered over approximately two meters. The main part of the gravel sheet does not contain Rocourt tephra minerals. This means that these gravels have been deposited before 90 000 BP and that the current level of the bed is the same as before the gravel sheet accumulation.



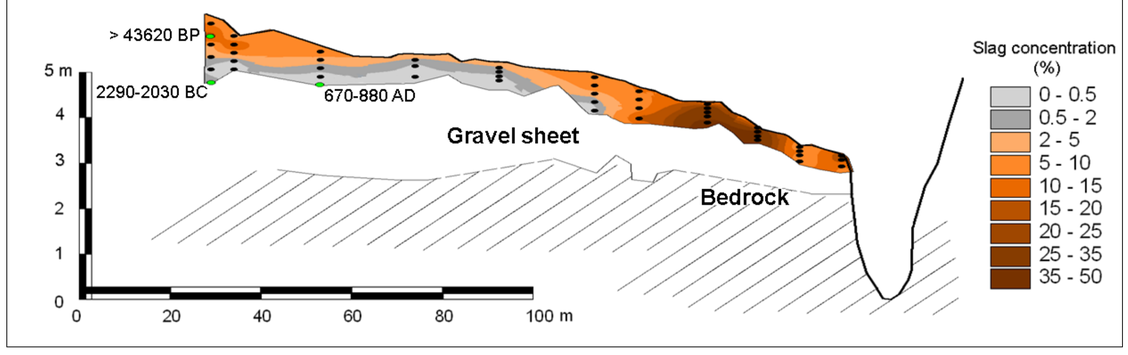
Cross section of the valley floor of the Aisne River at Roche-à-Frêne site.

- In the downstream part of the Ourthe River, the bedrock level under the lowest terrace is 6 m above the bedrock under the floodplain. The presence of Rocourt tephra minerals in this terrace indicate that the gravel sheet was deposited after the fallout of the tephra (73-90 Ka). The two samples collected at the base of the floodplain do not contain volcanic minerals but the upper samples contain Laacher tephra. So we can make the hypothesis that after the gravel deposition on the low terrace, the river incised the bedrock to a depth of 6 meters and after that accumulated about 2 meters of gravels before the fallout of the Laacher See tephra. Afterwards, an aggradation episode of 4 meters probably occurred during the Younger Dryas. Finally, the Ourthe River incised its gravel sheet to a depth of 1.5 meters.

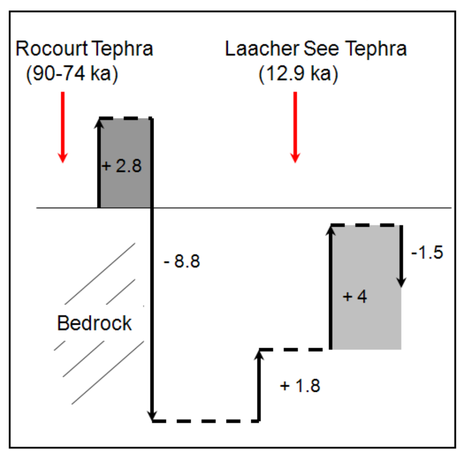


Thickness of the gravel sheet still present under the bed of the rivers in the Ourthe catchment (data from the geological survey, coring and penetrometric tests

Tephra content in the gravel sheet of the Ourthe valley near Liège (Colonster site) (modified from Juvigné, 1973)



^{14}C dating and slag concentration in a cross section of the Hoëgne River (Polleur). In this valley, the oldest metallurgic sites have been installed in 1350 AD.



Evolution of the bed level of the Ourthe river since the Rocourt Tephra fallout (according to data of Juvigné, 1973)

-Thanks to numerous radiocarbon datings, carried out on pieces of wood preserved at the contact between fine-grained deposits and the gravel sheet from several rivers from the Ardenne Massif, it appears that the level of the river beds has not changed since the beginning of the Holocene, even during the Little Ice Age. Only, in the Hoëgne River (Polleur cross section), a spectacular incision phase was observed after the Middle Ages (3.8m since 1350 AD). Nowadays the river is flows on the bedrock, 2.5 m under the base of the gravel sheet beneath the floodplain.

- Finally a palynological study of a peat bog, which has developed on the valley floor of the Lienne River, shows that an incision phase occurred at the Younger Dryas / Preboreal transition (about 1.5 m) (Denis *et al.*, 2013). This incision is also observed in the Aisne River, the Lembrée River and the Ourthe River.

Conclusion

Nowadays, Ardennian rivers flow on gravel sheets mainly inherited from the Younger Dryas, however some parts could be older than the Weichselian period (cf. Aisne River). The thickness of the gravel sheet still present under the river beds is very variable (from 10 m in the downstream part of the Ourthe River to less than 1 m in the upper catchments).

In some valleys, weathered bedrock has been observed under the gravel sheet to a thickness of several meters. This weathering hasn't been dated but is probably more recent than the gravel deposition.

Different phases of accumulation and incision over the last 100,000 years have been dated. Some evolutions can be clearly linked to climate changes but some modifications of bed levels also occurred during the Weichselian period and could be a response to the propagation of knickpoints in the fluvial networks

All the rivers studied show a relative stability of the bed level during the Holocene except the Hoëgne River which currently flows directly on the bedrock in several sectors.

References
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