Prospecting Middle Palaeolithic open-air sites in the Dutch-Belgian border area near Maastricht

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Abstract

Since 1981 a series of brickyard quarries to the north and west of Maastricht, in the municipalities of Maastricht (The Netherlands) and Lanaken (Belgium), have been intensively and successfully prospected for human artefacts and faunal remains from the Pleistocene by scrutinising the vertical sections of exposed loess, which in many places is over ten m deep. These efforts were accompanied by extensive geostratigraphic surveys, which have been crucially important in dating the finds and reconstructing the palaeolandscape. Excavation programmes as well as ancillary studies were subsequently carried out at three of these quarries: Maastricht-Belvédère, Veldwezelt-Hezerwater and Kesselt-Op de Schans, each of which yielded multiple Middle Palaeolithic occupation horizons.

This article describes the history of these excavations and studies, looking in some detail at the preliminary prospecting work that led to the discovery of this wealth of archaeological open-air sites. A separate description is provided of the litho- and chronostratigraphic frameworks of the three quarries, which has been key in establishing the chronology of Pleistocene occupation of this area. There is particular focus on the landscape and traces of occupation during the Belvédère Interglacial complex at Maastricht-Belvédère and the Weichselian Glacial at Veldwezelt-Hezerwater. The traces of fire and the macrofaunal remains encountered in the respective archaeological horizons are also discussed, and in particular their significance: are these natural phenomena or evidence of interventions by Pleistocene humans?

Key-words: Middle Palaeolithic, OIS 7, Maas basin, Province of Limburg, loess, open-air sites, macrofauna, fire.

Contents

1. History of Middle Palaeolithic research in the Maastricht area

1.1. Archaeological sites

The earliest finds of Middle Palaeolithic artefacts in the southern part of Dutch south Limburg date back to the second half of the 19th century. The first to be well-documented, though, are those from St. Geertruid-De Heij (around 1881) and Mesch-Steenberg (1938), where numerous flint artefacts were found, including several handaxes (Groenendijk & De Warrimont, 1995; De Warrimont, 1998; Van Haaren, 1968). In those early days it was archaeologists from nearby Belgium, in particular, who prospected the ploughed fields here. The last three decades of the 20th century saw an upsurge in prospecting activity in the wider area by regional archaeologists such as Felder (Dutch Geological Society), Roebroeks (now Leiden University), Groenendijk, De Warrimont (Archaeological Society of Limburg, and present author) and a dozen or so others from south Limburg and elsewhere. Around Banholt, Mheer-Hoogbos and St. Geertruid-De Heij, Neolithic open flint mines had previously been discovered (the last of the three with a vast complex of subterranean shafts and galleries), and these locations now all yielded surface finds from the Middle Palaeolithic, too.

Spurred on by these results, in 1980 a systematic survey of loess profiles exposed by quarrying was undertaken by Roebroeks and Felder. This yielded a number of Middle Palaeolithic finds, all from a secondary context (reworked or *ex situ* finds), including a handaxe and a Levallois flake from derived loess deposits in the ENCI quarry just south of Dutch Limburg's provincial capital Maastricht (Roebroeks, 1981).

In 1980 the first Middle Palaeolithic artefact was found at the now renowned site of Maastricht-Belvédère, a loess and gravel pit just north of the town where quarrying had exposed thick deposits of Pleistocene loam (Roebroeks, 1988). This find, by Felder, was followed by a systematic survey of the quarry by Roebroeks, Groenendijk and De Warrimont. Initially, the loess profiles yielded only secondary-context finds, but in March and July of 1981 the first primary-context sites (Sites A and B) were discovered by the present author, the first of a long series of undisturbed, primary context sites to be uncovered at Maastricht-Belvédère between 1981 and 1991 (Roebroeks, 1988; De Loecker, 2006).

This was followed several years later by the discovery of new primary context sites at two other loess quarries just over the Belgian border, about two and three km to the south-west: Veldwezelt-Hezerwater, where prospecting and excavations lasted from 1995 to 2005 (*e.g.* Groenendijk *et al.*, 1998; De Warrimont, 2002a; Bringmans, 2006) and Kesselt-Op de Schans, where prospecting began in 2001 and excavations are still in progress. In the first of these quarries, archaeological primary context sites from six different stratigraphic horizons dated to between 50,000 and 150,000 years ago have been investigated. In the second, a primary context site (Site 2) with flint artefacts and numerous charcoal fragments was discovered below a humic soil on 5 June, 2006. The horizon in question, provisionally dated to about 300,000 years ago, was excavated in 2007 by a team led by archaeologists from the Catholic University of Leuven, Belgium. The first site (Site 1) in this quarry was discovered several years earlier, in 2001. In what was essentially a rescue excavation it was investigated by a team led by Bringmans, also of Leuven University, who at the time was conducting a campaign at the nearby Veldwezelt-Hezerwater quarry. At both these quarries, extensive geological surveys were carried out by Meijs, presently working at the Rural Areas Department of the Dutch Limburg Provincial Executive. For photographs and a detailed description of the geological profiles in and around these various quarries, the reader is referred to the website run by Meijs: www.archeogeolab.nl.

The archaeological sites of the Maastricht-Belvédère quarry were excavated between 1981 and 1991 by a multidisciplinary team led by Roebroeks and yielded numerous flint artefacts as well as a rich Pleistocene micro- and macrofauna. In addition to Sites A and B, a total of fourteen other sites were discovered and excavated in this quarry (Roebroeks, 1988; De Loecker, 2006), some of them low-density, some high-density sites, and some yielding faunal remains and/or evidence of campfires in the form of charcoal or burned flint. These excavations have been extensively published; the work of the multidisciplinary team is described briefly below.

Between 1991 and 1995, some 50 km^2 of the Dutch-Belgian border area in the south of Limburg known as the Voerstreek and comprising the municipalities of Margraten (The Netherlands) and Voeren (Belgium) was systematically prospected by Groenendijk and De Warrimont. A full inventory was also drawn up of all known surface concentrations of Middle Palaeolithic artefacts in the wider trans-border region (Groenendijk & De Warrimont, 1995). The richest surface sites of this entire region, with impressive concentrations of weathered Middle Palaeolithic flints, are all to be found along the higher edges of the plateaus bordering the larger rivers: the Maas and its main tributaries, in particular the Voer and Geul. Most of these sites command an excellent view of the landscape, in particular the river valleys to the south and west. Further away from these rivers, on the central areas of the plateaus, there are far fewer sites, yielding far sparser concentrations of artefacts.

The large number of surface sites found along these plateau edges is to be explained by several factors. For the Palaeolithic occupants of this landscape, basic necessities were close at hand: fresh water from streams and rivers, and rich sources of flint from chalk outcrops and flint eluvium, as well as river gravels. For hunting communities, these elevated sites may also have been advantageous for tracking game. From the perspective of prospecting archaeologists, soil erosion of these more elevated parts of the landscape has meant that the loess deposits originally overlying the sites have often been conveniently removed, or are now shallow enough for ploughing to uncover still buried artefacts. Any sites within the valleys have, by contrast, become obscured from view by thousands of years of sedimentation and colluvial deposition.

Analysis of the flint assemblages found at these various Middle Palaeolithic surface sites (Groenendijk & De Warrimont, 1995; De Warrimont, 2000) shows clearly that the ratio of river and Maas terrace gravel flint (with rolled cortex) to flint from chalk outcrops or eluvium (with fresh cortex) is directly proportional to the distance from the nearest known Neolithic flint mines. In other words the greater that distance, the more artefacts are made of river gravel flint (table 1). This means that Middle Palaeolithic humans were already familiar with the flint resource areas exploited later on a larger scale by their Neolithic successors.

Middle Palaeolithic surface collections	Flint from Maas river terrace gravel [%]	Flint from chalk outcrop or flint eluvium [%]	Number of measured artefacts [n]	Distance to nearest flint mining area [m]
Mheer-Hoogbos 3	0	100	55	±250
Mheer-Hoogbos 1 & 2	32	68	66	±250
De Kaap (Heij) – St. Geertruid	24	76	141	±500
Snauwenberg	52	48	119	1250
Schoppemerheide	50	50	10	2500
Mescherheide	45	55	29	2750
Beekberg	55	45	22	3000
Geulle-Armenbosch	76	24	-	7000

Table 1. Main Middle Palaeolithic sites with artefacts from surface collections around the southern Dutch-Belgian border: relative quantities of flint from river gravel versus flint from chalk outcrop and flint eluvium, and distance to nearest prehistoric flint mine (Groenendijk & De Warrimont, 1995).
Note: '-' = unknown.

1.2. Prospecting the loess

In the wider region around south Limburg, excavations in loess deposits had likewise yielded Middle Palaeolithic artefacts by the early 20th century, the first of them in 1911 at Sainte-Walburge near Liège (Belgium). About fifty years later, in 1964, Bosinski (Cologne University) initiated a series of remarkably successful archaeological excavations in a loess quarry at Rheindahlen near Mönchengladbach (Germany), exposing multiple Middle Palaeolithic occupation horizons and recovering a wealth of artefacts. It was these excavations, among other things, that inspired Roebroeks, Groenendijk, Meijs and De Warrimont to start their extensive prospecting of the loess deposits around Maastricht, as described above. In 1981 the Maastricht-Belvédère quarry, where the loess and loamy sediments were exposed to a depth of up to ten m (figure 1), was deemed the most promising location for further study.

In the period 1981-1991, a team led by Roebroeks (Leiden University) conducted an extensive series of archaeological excavations. Between 1995 and 2005 prospecting work was continued by Groenendijk, Meijs and De Warrimont, now in the Hezerwater quarry at Veltwezelt (Belgium), a brickyard (loess) quarry just west of Maastricht (figure 2). As with Maastricht-Belvédère, this was a river valley environment, with sedimentation in both cases making for good preservation of the archaeological finds. At the Veldwezelt-Hezerwater quarry (figure 3) collaboration was instigated with Bringmans, himself from Veldwezelt, who between 1998 and 2003 led a series of archaeological excavations there under the auspices of the Laboratory of Prehistory, Catholic University of Leuven. In both cases the collaboration between regional archaeologists and academic institutes proved valuable, with the latter carrying out the more extensive excavations and providing the required materials, specialists and students. Many volunteers from neighbouring south Limburg also helped with the excavations, as did numerous students from universities from both The Netherlands and abroad. In the summer months there were often dozens of diggers and specialists at work, who in the end managed to excavate more than fifteen different archaeological primary context sites. These were located at a variety of levels in the two pits and yielded artefacts of varying age, providing a good picture of early human, *i.e.* Neanderthal life in this region. Following the excavations, the finds were analysed and published by specialists working at various institutes.

Figure 1. The Maastricht-Belvédère quarry during the excavation of Site K in 1987. Photograph by the author.

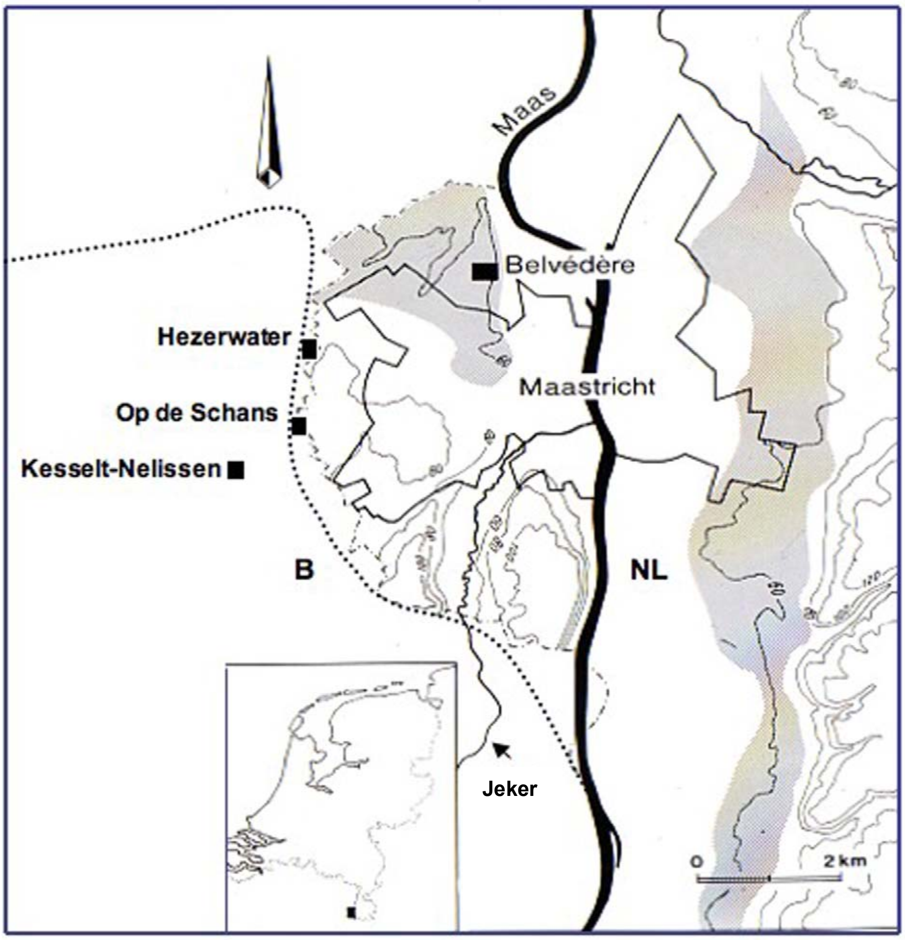

Figure 2. Location of the investigated brickyard loess quarries to the north and west of Maastricht in relation to the Caberg middle-terrace deposits of the river Maas (in grey). The Albert Canal is indicated by a dotted line. Based on: De Loecker (2006: 11).

Figure 3. The Veldwezelt-Hezerwater quarry during the 2002 archaeological campaign. Photograph by the author.

Regular prospecting of the various pits and intensive scraping and study of the exposed profiles, essential for tracking down these kinds of site, are virtually unfeasible for staff based at distant universities and other such institutes. This kind of work requires regional volunteers, people with an opportunity to follow the commercial loam-quarrying operations on a weekly and, if necessary, daily basis, scouring the vertical walls created as the soil is dug away, often in 'terraces' two to five m high. The archaeological sites lie deep underground, in many cases more than ten m below the present-day surface.

With their intensive prospecting, regional archaeologists have managed to track down many sites of potential interest over the years, undertaking exploratory excavations to assess their value. Subsequently, a number of well-preserved sites were selected that were deemed worthy of further study. In addition, comprehensive stratigraphic surveys were also carried out at several quarries where well-preserved finds had been recovered from interglacial and interstadial soils from four great ice age cycles. Besides a variety of stone tools used to work wood and butcher animals, as well as numerous flint-knapping flakes, or *débitage*, these prospecting efforts also yielded numerous bones of the animals from a variety of locations.

In these northerly regions of western Europe it was only the cool and temperate periods that were suitable for human habitation, not the coldest glacial and stadial stages of the ice ages. An understanding of the geo- and chronostratigraphic superposition of the sediments in the quarries is of key importance for dating the finds and also provides insight into the climate and landscape in which the Neanderthal population then lived. From the type of soils in which the undisturbed archaeological sites were discovered and from the finds themselves, conclusions can be drawn as to whether the contemporary landscape was tundra, steppe, taiga or, alternatively, the deciduous open forest associated with a warm temperate climate.

Figure 4 is a long-term climate curve showing the period with sediments exposed in the quarries of Maastricht-Belvédère, Veldwezelt-Hezerwater and Kesselt-Op de Schans. The richest of the Maastricht-Belvédère sites have been dated to between 220,000 and 250,000 years ago. One of the finest finds was a flint knife recovered from among the bones of a steppe rhinoceros at Site G (De Warrimont, 2003b: 172). By microscopically analysing the traces of wear on this knife, Van Gijn (1988) was able to demonstrate that the tool had been used to butcher pachyderms (a group including elephants and rhinos), an excellent match to the bones recovered. What we had here was a hunting camp, which also yielded traces of the intentional use of fire.

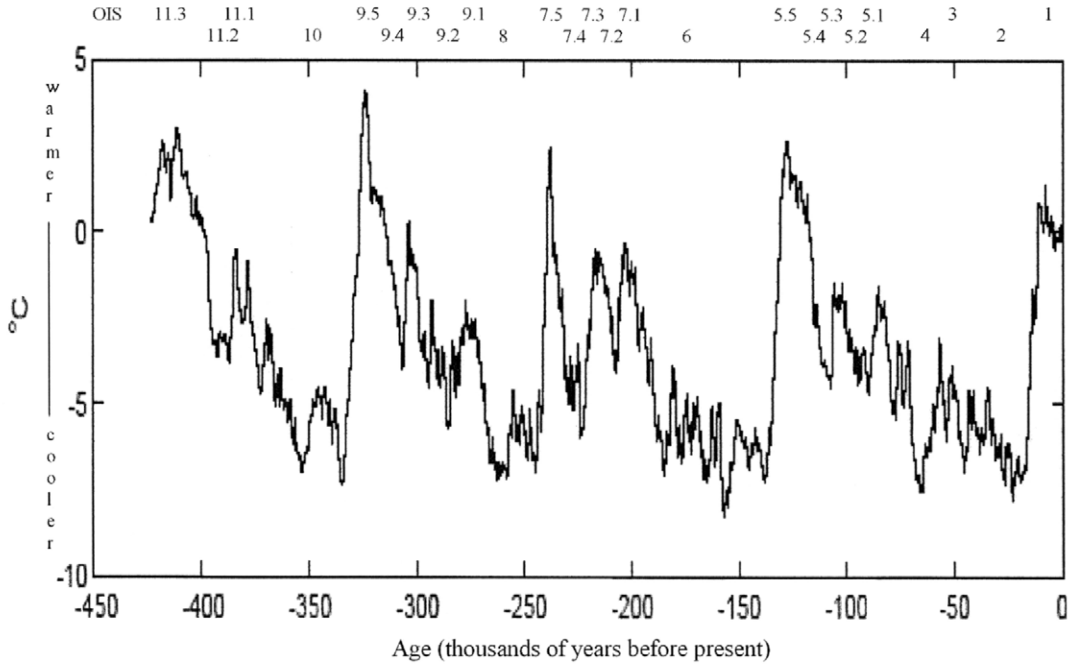

Figure 4. Climate curve for the last 425,000 years: the period with sediments exposed in the quarries of Maastricht-Belvédère, Veldwezelt-Hezerwater and Kesselt-Op de Schans. Based on the Vostok ice core - Deuterium curve, a high-resolution temperature curve often used as a global climate indicator for the late Middle Pleistocene and Late Pleistocene. Oxygen Isotope Stages (OIS) added by the author.

It was a warm-temperate climate in which steppe rhinoceros (*Dicerorhinus hemitoechus*), red deer, straight-tusked elephant and roe deer as well as the now extinct giant deer were among the animals that thrived. From more recent sediments, an ice-age fauna was recovered that included horse and woolly rhinoceros. In the Veldwezelt-Hezerwater quarry we discovered, among other things, archaeological horizons from the Weichselian Middle Pleniglacial along with the remains of animals associated with a loess steppe, also known as 'mammoth steppe'. Among the stone tools left behind by the Neanderthals we found the bones of horse, woolly rhinoceros, mammoth, Bos/Bison, wild ass and reindeer. There were also carnivorous species, including cave lion and cave hyena. The presence of burrowing animals like badger and numerous moles indicates that this phase of the Weichselian Middle Pleniglacial was not extremely cold.

With all this information we have gained a detailed picture of Neanderthal campsites and the activities undertaken there, the changes in climate that have occurred over the last 300,000 years, and the main periods of human occupation in our region. The presence of fresh water and flint in the gravel of the Maas, Jeker and Hezerwater once more explain the wealth of archaeological sites found to date. The water of these rivers was of vital importance for human occupation of the landscape and also attracted the game they hunted.

1.3. Multidisciplinary research

Besides those named above, all of whom have contributed extensively to Middle Palaeolithic research in the region under study, over the past 25 years numerous regional volunteers have also helped with excavations at the various quarries, as well as many others from elsewhere in The Netherlands and Belgium. Several generations of students from Leiden and Leuven have taken part in the excavation campaigns, supported by students from a number of other universities, including those of Gent (Belgium), Groningen (The Netherlands) and Lethbridge (Canada).

Right from the start, the 11-year campaign (1981-1991) at the Maastricht-Belvédère quarry was taken to hand by a multidisciplinary team, supervised by Roebroeks (University of Leiden). Over the years, this team produced an important series of detailed studies. On the archaeological side there were studies of Middle Palaeolithic technology by De Loecker and microwear studies of flint artefacts by Van Gijn (both University of Leiden), while thermoluminescence dating of key finds was carried out by Huxtable, Aitken (both Oxford University) and Debenham (British Museum, London). In complementary research efforts, the geology was studied by Vandenberghe (Free University of Amsterdam), soil micromorphology by Mücher (University of Amsterdam) and Huijzer (Free University of Amsterdam), palaeontology by Van Kolfschoten (University of Leiden) and malacology (freshwater molluscs) by Meijer (Netherlands Geological Survey), Kuijper and Duistermaat (both University of Leiden), while heavy mineral studies were performed by Krook (Free University Amsterdam) and Meijs (then University of Utrecht). Charcoal was identified by Schoch (Swiss Federal Institute of Forestry Research).

At the Veldwezelt-Hezerwater quarry several years later, the programme of excavations was under the overall supervision of Vermeersch (Catholic University of Leuven), with successive campaigns being led by Vanmontfort (1998), Bubel (1999-2000) and Bringmans (2000-2004), who also performed all the lithic analyses (Bringmans, 2006). At this quarry, geological studies were carried out by Gullentops (Catholic University of Leuven) and Meijs, soil studies by Schirmer and Ickinger (both Heinrich-Heine University, Düsseldorf) and charcoal analysis by Damblon (KBIN, Brussels), while selected fauna was identified by Cordy (University of Liège). The most recent excavations, at the Kesselt-Op de Schans quarry, have to date been carried out under the supervision of Van Peer (Catholic University of Leuven).

Besides these major campaigns and studies, over the years there have also been numerous smaller-scale studies focusing on individual sites and issues. Together, the results of this extensive programme of research give us a good idea of the occupation of this region by early humans, *i.e*. Neanderthals. We are now in a position to understand something of the nature and structure of their camps in this 'lowland' region in the Maas basin, providing a window on early human behaviour here. We have a better idea of the technologies they used and the landscape and environment in which they lived and moved (Roebroeks, 1988; Van Kolfschoten *et al*., 1985, 1993; De Loecker, 2006; Bringmans, 2006). And, importantly, we now have a far clearer picture of when Neanderthal man was here, in terms of both absolute chronology and phases of glacial cycles.

2. Loess stratigraphy of the Lower Rhine and Maas basins

When the Albert Canal to the west of Maastricht was being widened in the 1980s (figure 5), Bosch, Felder (then of the Geological Bureau, Heerlen) and Meijs carried out a detailed geological survey of the exposed profile, which was about six km long and in some places towered 40 m high. It comprises Cretaceous and Tertiary deposits, several Pleistocene terraces of the River Maas and a stack of wind-blown loess deposits. The survey revealed that these latter deposits, which can be up to 15 m deep in this area, contain a series of interstadial and interglacial soils that together encompass the last half million years. The profile was published in the 'Eiszeitalter und Gegenwart' by Meijs (2002), who has since undertaken a series of more detailed surveys of newly exposed profiles further along the Albert Canal and in nearby loess quarries to augment the original work. All the quarries concerned are in the vicinity of the canal. These key profiles serve as something approaching a 'gold standard' for the geological and pedological studies in the loess quarries excavated archaeologically.

In 2002 Gullentops & Meijs published a study of the loess sequences in the region of Belgium known as the northern Haspengouw (Gullentops & Meijs, 2002). In the Lower Rhine basin of Germany, meanwhile, Schirmer had been studying loess profiles containing interglacial soils from approximately the same period (Schirmer, 2002a) and had compared them with the profiles from the Maas basin that concern us here (Schirmer, 2002b). Of particular note are two interglacial soil complexes in the Lower Rhine basin: the Erft and Rur soil complexes, which have been correlated with MIS 7 and MIS 9 (Marine Isotope Stage (MIS) = Oxygen Isotope Stage (OIS) (Jouzel *et al*., 2007: 793-794), respectively. Interestingly, these are both interglacial soil complexes, a phenomenon also observed in the MIS 7 soil at the Maastricht-Belvédère quarry (Huijzer & Mücher, 1993).

3. Maastricht-Belvédère: the lithostratigraphic framework

Following a decade of multi-disciplinary fieldwork and archaeological excavations between 1981 and 1991, the main geological, palaeontological and chronological findings and conclusions were presented in two key publications in 'Mededelingen Rijks Geologische Dienst' 39-1 (1985) en 47 (1993). In these early years of research one of the main objectives was to determine the age of the archaeological find horizons. The conclusion drawn, based mainly on biostratigraphical reasoning, was that the Belvédère Interglacial should be regarded as an interglacial within the Saalian. Although micromorphological studies had shown that the Belvédère

Figure 5. Widening of the Albert Canal at Kesselt in 1983, showing a succession of limestone (bottom), Tertiary sand, Maas gravel and loess, with a succession of five different interglacial soils, on top. Photograph by the author.

Interglacial was associated with an interglacial pedocomplex (sol or soil complex) consisting of two distinct interglacial Luvisols, K1s and K2s, this did not receive the attention it deserved.

The Belvédère Interglacial was correlated with the intra-Saalian warm-temperate stage OIS 7, dated to 250 ka, *i.e.* to an interglacial stage between the Eemian and the Holsteinian. This was based on absolute TL and ESR dates derived from burned flint and molluscs from the oldest Unit IV archaeological find horizon and on biostratigraphical arguments from several micro- and macrofaunas from Unit IV. However, the interglacial macrofauna from Unit IV, published for the Belvédère Interglacial OIS 7 by Van Kolfschoten (1988), is a mixed fauna gathered from the stratigraphical units d3 through to e5 (see below).

3.1. Brief outline of a detailed lithostratigraphic framework for the Maastricht-Belvédère quarry

This section presents the complete sediment sequences of the Maastricht-Belvédère gravel and loess quarry with reference to a series of figures and photographs (see also www.archeogeolab.nl). Figure 2, first, is a map showing the location of the Maastricht-Belvédère quarry. Figure 6 is an idealized standard profile of the quarry, while figure 7 is a photograph of one of the quarry walls. Table 2 provides an overview of the

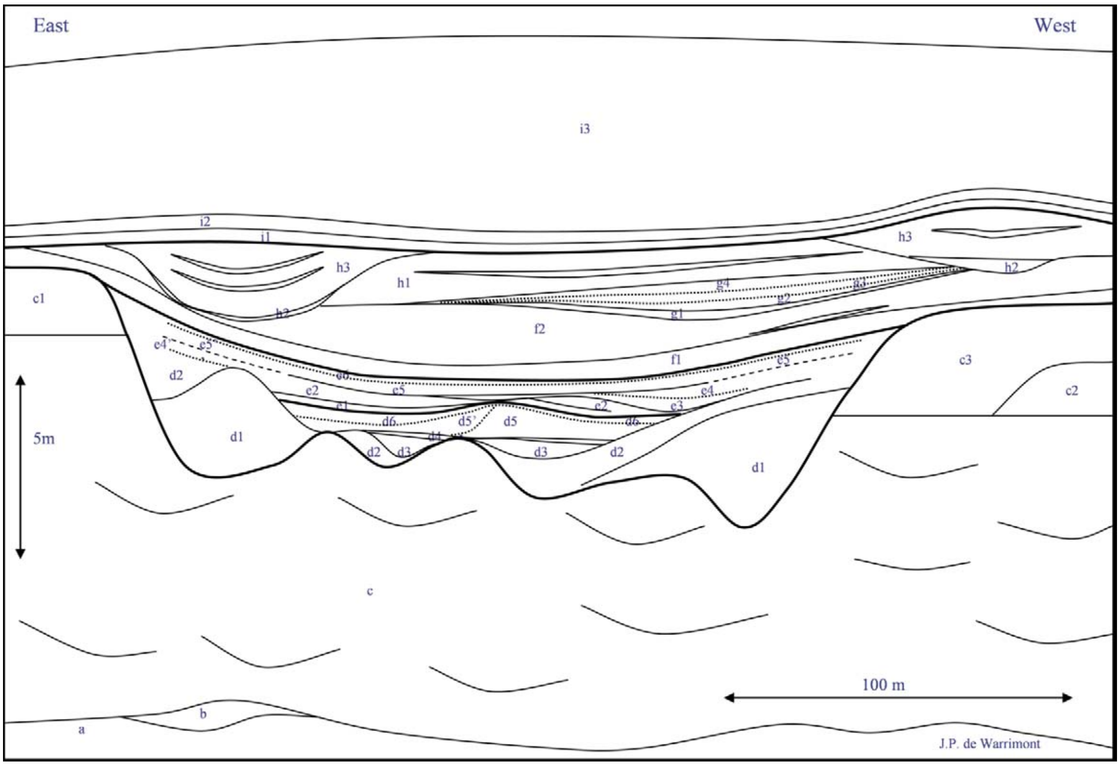

Figure 6. Idealized profile of the southern part of the Maastricht-Belvédère quarry: based on sediment sequences near the main archaeological sites and on micromorphological studies of the Pleistocene soils. Figure by the author.

Figure 7. A well exposed quarry wall at Maastricht-Belvédère in 1987. Photograph by the author. Note: A1, A2 and A3 are the three main archaeological levels present in this quarry. A1 = Unit IV, level I; A2 = Unit IV, level II; A3 = Site F level (Weichselian Early Glacial).

Lithological units, in chronological sequence	Archaeological sites: **bold**: primary context sites, proven; *italics*: secondary context sites, proven; other: possible primary context sites, unproven	Erosional phases	Soils	OIS units and assumed age of sediments in kiloyears BP [ka]
i3			Holocene P.S.	
i2			Nagelbeek	OIS 2
i1				
		EL12 (deflation horizon)		
h3				
h2	*Site E*			
		EL11 (stone line)		OIS 3
h1				
		EL10 (stone line)		
g4				
g3			Warneton	OIS 4
g2				
	Site J	EL9 (stone line)		OIS 5: 73ka
g1				
		EL8 (truncation of Luvisol K3s)		OIS 5
f2			Rocourt P.S. Luvisol K3s	OIS 5 OIS 6
		EL7 (stone line)		
f1				
		EL6 (truncation of Luvisol K2s)		
e6				
e5/e5'	e5 : **site N** e5': **site A, D, F, H, K**			OIS 7.3: 218ka
e4			Luvisol K2s	
e3				
		EL5		OIS 7.4
e2	Site N, Level X			
e1	*Site L (1988)*			
		EL4 (truncation of Luvisol K1s)		
d6	Site L (1987)			
d5/d5'				
d4	*Site M*			
		EL3	Luvisol K1s	
d3	**Site B, C, G**			
		EL2 (stone line)		OIS 7.5: 250ka
d2				
d1				
		EL1 (main erosion of the Jeker)		
c3				
c2				
c1				OIS 8.02 OIS 8 OIS 8.2
c				
		Main erosion of the River Maas		

Table 2. Lithological units from the Pleistocene deposits at Maastricht-Belvédère, with archaeological sites, erosional phases, soils and Oxygen Isotopic Stages (OIS). Note: 'P.S.' = post-sedimentary soil.

archaeological find horizons from the Belvédère Interglacial (Unit IV) and the Weichselian deposits, placing them in a framework of erosional phases and OIS and giving the presumed age of certain lithostratigraphic units. For more details of the lithological units, see Vandenberghe *et al.* (1993).

The idealized profile comprises nine sediment sequences:

1 The gravels, sands and loams (the units c, c1-c3) deposited by the river Maas, the oldest Pleistocene sediments in the Maastricht-Belvédère quarry, underlying it in its entirety.

2 & 3 In the central section of these Maas deposits, a new gully system was eroded by the river Jeker, a tributary of the Maas. This system is about 200 m wide and consists of gravel, sand, loam and clay from the river Jeker (d1-d3).

4 & 5 As the Jeker changed its course, away from the site, the fluvial depression was partially filled, in a cyclic succession of erosion and sediment accumulation, with sand, loam, clay and calcareous tufa (*marshchalk*) (d4-d6, e1-e2 & e3-e6). In this sequence two interglacial Luvisols (K1s and K2s) are present. These paleosols are part of the Belvédère Interglacial pedocomplex and form the lower and upper part of what is known as Unit IV (figures 8 & 9).

6 Towards the end of the Saalian the remaining central depression was filled further with loess-derived colluvia (f1-f2), on top of which a third interglacial Luvisol (K3s) is present. This has been posited as being equivalent to the so-called Rocourt soil, formed during the Eemian.

7 & 8 On top of the Rocourt soil is a system of Weichselian deposits, with Early Glacial humic soils (g2-g4), resembling the so-called 'Warneton soil', followed by Middle Pleniglacial loess (h1-h3).

9 The upper system starts with a deflation horizon (i1) and consists of a thick cover of eolian loess (i2-i3), on top of which lies the Holocene soil.

Figure 8. Belvédère Interglacial complex: lower part of Unit IV, with well-exposed sediments below the greyish-white calcareous tufa (at the centre of the photo). Photograph by the author.

In the southern part of the Maastricht-Belvédère quarry the deposits between the calcareous tufa d5 and the find horizon e5 are significantly thicker than in the northern part, near Sites B, C and G. In the southern part of the 350-m-long quarry, the elevation of e5 is nearly two m higher than in the north. In part, this is due to the fall of the former river Jeker, but is also the result of greater erosional activity in the north, where the upper part of Unit IV (e1-e6) is less well preserved.

Below, the nomenclature formerly used for the (sub-)units (Vandenberghe *et al.*, 1993), has been added in brackets, as has the thickness of the units.

Figure 9. Belvédère Interglacial complex: Upper part of Unit IV, with well-exposed sediments above the greyish-white calcareous tufa (about 80 cm thick). Erosion-accumulation cycles EL3, EL4 & EL5 are, respectively, below and above the tufa and above the yellow-green level e2. Photograph by the author.

Description

a (1):	Limestone of Palaeocene age.
b (2):	Tertiary grey-green clayey sands: Tongeren formation (depth: 0-1 m).

Erosion-accumulation phase 1

c (3/IIIA):	Maas gravel with channels filled with sand, loam and clay (5-9 m) and large-amplitude cryoturbations. The sediment shows a high Vosges heavy mineral content. In the centre of this gravel unit, a channel filled with clay, charcoal, molluscs and leaf imprints was found: OIS 8 (De Warrimont, 2002b: 7).
c1 (4.7/IIIB):	Brown-red, laminated loamy sands, with shallow gravel layers (0-1.5 m) locally in the eastern part of the pit, with frost fissures; high Vosges heavy mineral content.
c2 (4.1/IIIB):	In the western part of the pit, pale yellow-brown, locally calcareous, finely-laminated silty sands with frost fissures and microfauna (0-1.5 m); low Vosges heavy mineral content.
c3 (4.2/IIIB):	Massive layer with yellowish-brown sandy silt deposits and discontinuous gravel beds in the western part of the pit (0-2.5 m); low Vosges heavy mineral content.

Erosion-accumulation phase 2

EL1: Erosional activity of small, meandering river in the centre of the quarry, with incised meanders reaching a depth of up to 4 m.
- d1 (IVA): Light-grey finely-laminated sands, with intercalated layers of gravel; cryoturbations and frost cracks present (0-1 m).
- d2 (IVA): Light-grey, laminated, loamy fine sands, locally calcareous (0-1 m).

EL2: Erosion level.
- d3 (IVB/4.5A): Olive-green, silty-calcareous clay, locally decalcified: Sites B, C, G (0-0.5 m), main archaeological layer.

Erosion-accumulation phase 3

EL3: Erosion level, locally a stone line.
- d4 (IVCα): Yellow-red sand with some gravel (0-0.3 m): the archaeological layer of Site M.
- d5/d5' (IVCα/4.5B): Greyish-white calcareous tufa (d5) with embedded silt and fine sand grains, or the residue of dissolved tufa (d5') (0-0.8 m).
- d6 (IVCα): Green clay (0-0.2 m): the archaeological level of Site L (May 1987).

Erosion-accumulation phase 4

EL4: Erosion level. Truncation of Luvisol K1s.
- e1 (IVCβ): Yellow-red, laminated sands and silts (0-0.1 m). Site L, test pit (January 1988).
- e2 (IVCβ/4.5C): Mixed horizon with yellow-green to red-brown clay, silt or sand, locally with multiple erosion gullies and layered greyish-brown and yellow-brown silts and sands (0-0.3 m): archaeological layer of Site N: Level X.

Erosion-accumulation phase 5

EL5: Erosion level.
- e3 (IVCβ): Red-brown loam with stones (in general 0-0.1 m; locally one m).
- e4 (IVCβ): Olive or greyish-brown loam (PBZ) (0-0.2 m).
- e5 (IVCβ/4.5D): Greyish-brown clayey loam and clay (BZ) with desiccation cracks: Site N (0-0.3 m): main archaeological layer.
- e6 (IVCβ/4.5D): Brownish-yellow clayey loam (0-0.1 m).

Erosion-accumulation phase 6

EL6: Erosion level with a marked gravel layer (the so-called 'slate layer'). Large stones (diameter 30 cm) locally present. Truncation of Luvisol K2s.
- f1 (VA/5.1): Yellowish-brown sandy silt (about 25 cm).

EL7: Erosion level (stone line).
- f2 (VB/5.2): Yellow-brown or yellow-red silt with a pale, laminated, grey gelic gleysol at its base with cryoturbations (0.5-2 m).

Erosion-accumulation phase 7

EL8: Erosion level (stone line). Truncation of Luvisol K3s.
- g1 (6.1): Greyish-white silt, bleached horizon with frost fissures (0-0.2 m).

EL9: Erosion level (stone line). Site J: main archaeological layer.
- g2 (6.2): Dark-greyish layer of displaced soil material: humic zone 1 (0-0.2 m).
- g3 (6.2): Grey silt loam: humic zone 2 (0-0.5 m).
- g4 (6.2): Dark-greyish silt loam: humic zone 3 (0-1 m).

Erosion-accumulation phase 8

EL10: Erosion level (truncation of humic horizons).
- h1 (6.3): Pale-brown, slightly calcareous, silt loam deposits and frost cracks with pale tundra gley horizon or laminated reworked loess (0-3 m).

EL11: Erosion level.
h2: Reddish-brown laminated gritty layer: Site E (0-0.3 m).
h3 (6.5): Irregularly layered or laminated yellow and brown loess, with two grey gelic gleysols (0-0.2 m).

Erosion-accumulation phase 9

EL12: Erosion level caused by deflation.
i1 (6.4): Yellow to yellow-red, laminated, sandy, reworked loess and gravel with large cryoturbation structures: the so-called Patina Layer (0-0.3 m).
i2 (7): Pale geyish-brown loess (0-0.5 m). Weak humic gelic gleysol, the so-called 'tongued horizon of Nagelbeek'.
i3 (7): Yellowish loess (max. six m) with a grey gelic gleysol topped by the red-brown Holocene Luvisol (~ seven m).

Remarks:

- i1 to i3 are present throughout the Maastricht-Belvédère quarry.
- d1 to e6 are present in the central part of the quarry.
- c2 and c3 are present in the western part.
- c1 is present in the eastern part.
- b is locally present.
- a and c are present throughout the quarry.

The erosion-accumulation phases in the higher topographic portions of the former Jeker gully system near the main archaeological sites A, D, F, H and K can be summarised as follows:

Erosion-accumulation phase 2

EL1: Erosion level.
d1 (IVA): Light-grey, laminated sands and gravel layers (0-1 m).
d2 (IVA): Yellow-brown, laminated sands (up to 1.5 m). Horizon with a steppe fauna.

Erosion-accumulation phase 5

EL5: Gravel layer (a stone line; but locally a gravel layer up to 0.3 m thick). This is an important time gap, with erosion-accumulation phases 3 & 4 absent.
e4' (5.1): Yellowish-brown sandy loam, (0-0.3 m).
e5' (5.1): Mottled zone VZ (Dutch: *vlekkenzone*): yellowish-brown sandy loam with very pale brown mottles, locally with some gravel (0-0.4 m). The main archaeological layer. This horizon e5' is the dry facies, higher in the palaeotopography of the former landscape, of horizon e5.
e6 (5.1): Brownish-yellow silt loam (locally up to 0.2 m).

Erosion-accumulation phase 6

EL6: Erosion level with marked gravel layer: SL = slate layer, truncation of Luvisol K2s.

3.2. Two separate interglacial periods within OIS 7 at Maastricht-Belvédère

In 'Beyond the site: The Saalian archaeological record at Maastricht-Belvédère (the Netherlands)', De Loecker (2006) published a typo-technological analysis of the Middle-Palaeolithic Saalian flint artefacts; chapter 2 was dedicated to the 'geology, palaeoenvironment and dating' of what is referred to as the Belvédère Interglacial. De Loecker's stratigraphical scheme and short chronology are incorrect, however, and are based on inaccurate interpretations of the 1993 and earlier studies. The first interglacial Luvisol is not even mentioned, and in chapter 5 De Loecker (*ibidem*: 230) writes: "As these [Unit IV archaeological] assemblages were probably all formed in the same climatic optimum, it can be suggested that some of the inter-site differences are the result of cultural site formation processes." (Remark between square brackets by the author). He also assumed, without further explanation, that the deposits from Unit IV containing the artefacts were related to the river Maas.

Against this background, let us now turn to the three lines of reasoning behind the analysis presented here. Since 1993 many new high-resolution, long-term chronological records have been published, based on a variety of proxies including the pollen content of land-derived sediments, soil sequences in loess, the pollen and oxygen isotope contents of deep-sea sediments and the chemical composition of ice cores from Greenland and the Antarctic.

In the context of Maastricht-Belvédère, stratigraphical fieldwork was continued after 1993 at several other quarries near the Dutch-Belgian border, not far from the original site. Here, additional information was gathered on the detailed nature of interglacial soil complexes, including, among others, the exceptionally detailed Rocourt soil complex exposed in the Veldwezelt-Hezerwater quarry, which also developed in a sediment trap, in this case related to the river valley of another tributary of the river Maas, the Hezerwater (De Warrimont, 2002a; Meijs, 2006b; Bringmans, 2006).

Based on this knowledge and on a renewed in-depth analysis of the old reports and long study of an extensive collection of photographs from the Maastricht-Belvédère quarry (see: www.archeogeolab.nl), it is now clear that the deposits from Unit IV belong to two separate interglacial periods within OIS 7 (De Warrimont, 2002b). The oldest archaeological find horizon d3 is part of the interglacial OIS 7.5, while the archaeological find horizon e5/e5' is part of the younger interglacial OIS 7.3 (figure 10). An additional argument for the complex nature of OIS 7 comes from the abundant literature that has meanwhile become available (Desprat *et al.*, 2006; Reille *et al.*, 1998; Spahni *et al.*, 2005; Martrat *et al.*, 2004; Tzedakis *et al.*, 2003, 2004; Prokopenko *et al.*, 2002; Schirmer, 2002a,b). The biostratigraphical evidence from Maastricht-Belvédère shows that during the human occupation of level d3 the first interglacial was already at its maximum (Meijer, 1985; Duistermaat, 1993). The macrofauna from level d3-d5, with straight-tusked elephant, steppe rhinoceros, Bos/Bison, red deer, giant deer and roe deer, differs significantly from the fauna in e5 (Site N), with horse, red deer and Bos/Bison. In the lower find horizon, horse is lacking, while in the upper find horizon, giant deer, roe deer, straight-tusked elephant and steppe rhinoceros are absent. Also the charcoal contents from level d3 (ash and coniferous at Site C) (Roebroeks, 1988: 35) and e5' (pine at Site K) (De Loecker, 2006: 189) are different.

Micromorphological studies have shown the real nature of this Belvédère Interglacial pedocomplex to be concurrent with OIS 7 (195-251 ka) (Huijzer & Mücher, 1993). Discussing the palaeosols K1s and K2s, they write (1993: 37): "It may be concluded that both in the sedimentary and palaeopedological environment no major breaks have been recorded during the K1 and K2 cycles. The K1s and K2s palaeosols, divided by a restricted sedimentary sequence, are interpreted as a pedocomplex that was formed in an intra-Saalian-Interglacial period, *i.e.* the 'Belvédère-Interglacial' (Vandenberghe *et al.*, 1993). Consequently, the K1s and K2s palaeosols are defined as the 'Belvédère Interglacial pedocomplex'; and in discussing the second cycle of soil formation, Mücher (1985: 26) stated: "The presence of the clear renewed lamination […] in combination with another type of illuviation phenomena is in support of another second cycle with sedimentation and soil formation, and not of a continuation of the first cycle."

Between the main archaeological find horizons from Unit IV, there are three distinct erosion-accumulation cycles, including EL3, EL4 & EL5 (figure 9). From our sedimentary studies in the Veldwezeld-Hezerwater quarry and from the literature, we know that these erosion-accumulation cycles are forced by climatic cycles (Kukla, 1977; Van den Berg, 1996). High-resolution climate records like the air-temperature δD record from Vostok (figure 4) show some climatic fluctuation during stadial OIS 7.4 (Desprat *et al.*, 2006): a Breviglacial *sensu* Schirmer (Schirmer, 2002a: 21; Ikinger & Schirmer, 2002). Based on this evidence, the proposal is to correlate the sediment cycle e1-e2 at Maastricht-Belvédère, and thus also the archaeological Site N: Level X (Timmermans, 1989), with an interstadial within this Breviglacial period OIS 7.4 (table 2).

3.3. Evidence for OIS 7.5 and OIS 7.3 archaeological horizons at Maastricht-Belvédère

A mollusc fauna from Maastricht-Belvédère was studied by Meijer (1985) and, based on biostratigraphical arguments, was also placed between the Eemian and Holsteinian. In 1993 a preliminary Amino Acid Epimerization age was given to the freshwater mollusc *Corbicula fluminalis*, from the lower part of Unit IV at Maastricht-Belvédère (Bates, 1993). Based on this study a pre-Cromer (West-Runton) age for these sediments was proposed, far older than the other age indicators from this site.

In a more recent publication, Meijer & Cleveringa (2003) correlate the lower find horizon from Maastricht-Belvédère Unit IV with OIS 9. This is based on a larger Amino Acid Racemization (AAR) study, in which they developed a chronological system comprising five AAR zones (A-E), with Maastricht-Belvédère slotting into zone D and correlating with OIS 9. This correlation is based on the assumption that zones A through E match, successively, the Holocene (A), the Eemian (B), OIS 7 (C), OIS 9 (D) and OIS 11 (E).

Figure 10. Belvédère Interglacial complex: Unit IV, with Site N (greyisch level e5, above the scraper) and Site M (in level d4, below the spatula). Photograph by the author.

An alternative line of reasoning can be taken, however, if it is assumed that OIS 7 consists of two separate interglacials (an OIS 7.1-3 complex, and OIS 7.5). That would place the lower Belvédère find horizon (zone D) in OIS 7.5 and zone C in OIS 7.1-3. In this AAR study two absolute OSL dates are available for zone C (219 & 231 ka), and we have, furthermore, the TL dates of 250 ka (Van Kolfschoten *et al.*, 1993) for the lower level at Maastricht-Belvédère (zone D) and 218 ka (De Loecker, 2006: 22) for the upper level (zone C). This alternative chronology is thus well founded.

To correlate the lower find horizon at Maastricht-Belvédère with OIS 9, as Meijer & Cleveringa propose, creates several complications. One consequence is that this would shift the Maas deposits (c, c1-c3) from the proposed age of OIS 8 to OIS 10. This conflicts with our understanding of the Maas terrace sequence (Van Kolfschoten *et al.*, 1993: 84) and with geologists' assumptions as to the general chronological development of the River Maas terrace system, with the tectonic upheaval of south Limburg during the Pleistocene and the forcing of the euglacials (such as OIS 2, 4, 6, 8, 10) being seen as the prime movers of terrace development (Van de Berg, 1996).

Based on the results of heavy-mineral studies by Krook (1993), the Toul event (the capture of the Maas by the Moselle near Toul) can be recognised at Maastricht-Belvédère in Maas river deposits (c, c1-c3). Recent studies on river terrace sequences near Toul, in the Maas, Moselle and Meurthe region (eastern Paris Basin, France), confirm an age of OIS 8 for the Toul event (Cordier *et al.*, 2004, 2005, 2006; Losson *et al.*, 2001). The oldest Moselle/Meurthe terraces after the Toul event correlate with OIS 6, moreover (Cordier *et al.*, 2006).

There is an additional argument for dating the lower find horizon at Maastricht-Belvédère to OIS 7.5. In their extended abstract, Meijer & Cleveringa remark that zone D is a zone without marine deposits on the existing land surface. This means that zone D is equivalent to a low-sea-level interglacial. There is growing evidence that OIS 7.5 is an interglacial with a relatively low sea level, lower than OIS 11, OIS 9, OIS 7.3, OIS 7.1, OIS 5.5 and OIS 1 (Thompson *et al*., 2006; Robinson *et al*., 2002; Siddall *et al*., 2003). At Maastricht-Belvédère this fits in well with the open character of the forests higher in the palaeotopography during the climate optimum of the lower interglacial (Van Kolfschoten, 1988: 38; Meijer, 1985: 96; Duistermaat, 1993: 64), with the presence of a mollusc like *Azeca goodalli* (Duistermaat, 1993), rodents like *Microtus agrestis* and *Microtus arvalis* (Van Kolfschoten, 1988) and mammals like steppe rhinoceros and giant deer. It points to a continental influence during this interglacial OIS 7.5 climatic optimum. The forest ratio, derived from the malacological fauna, was 75% at its maximum, and thus significantly lower than it was during the Holocene Atlantic, with a forest ratio of 95% (Duistermaat, 1993: 63). This hypothesis is supported by the available archaeological evidence, with clear human occupation during this climate optimum (Meijer, 1985; Duistermaat, 1993).

3.4. Evidence for river Jeker sediments at Maastricht-Belvédère

The arguments for correlating the deposits d1-d3 from Unit IV with the river Jeker rather than the river Maas can be summarised as follows: the large age difference between the main archaeological find horizons in Unit IV (250 ka versus 218 ka), the mineral content of the Unit IV sediments (Krook, 1993: 28), the small scale of the Unit IV gully system (Vandenberghe, 1993: 22), and last but not least the presence of the calcareous tufa, a phenomenon typical of the Jeker valley. In Maastricht, for instance, as well as at other places in the present-day Jeker valley and its tributary valleys, many localities with such tufa are known (personal communication Dijkman and Meijs), among them a Holocene Atlantic site in Kanne (Meijer, 1985: 96; Vermeersch *et al*., 1985) and the former Mabro site in the city of Maastricht.

In the vicinity of the Maastricht-Belvédère quarry the Caberg middle-terrace of the river Maas is over seven km wide (figure 2), and during this sedimentation phase the Maas could sometimes well have flowed more than three km to the east of its present-day channel. During such a period the river Jeker could therefore readily have reached the locality of the Maastricht-Belvédère quarry, by taking a northern direction parallel to the 60 m altitude contour (also shown in the figure).

4. Veldwezelt-Hezerwater: the chronostratigraphic framework and archaeological horizons

In the Hezerwater brickyard (loess) quarry at Veldwezelt, formerly exploited by the firm Vandersanden Steenfabrieken just over the Belgian border to the west of Maastricht (figure 2), magnificent soil profiles have been exposed through ancient channels of the Hezerwater brook (figure 11). Between 1995 and 2002 a programme of extensive prospecting studies was carried out here, and the results were used by the present author to elaborate the chronostratigraphic framework of the various soil profiles (De Warrimont, 2003a). Following the discovery of archaeological finds at multiple sites in this quarry and preliminary investigations, these sites were excavated under the supervision of Vermeersch (Catholic University of Leuven). Most of the data on these excavations have been reported by Bringmans (2006).

4.1. Soil series

As investigations at this quarry progressed, it soon became clear that in the course of the Saalian and Weichselian the Hezerwater brook had shifted from west to east, with the west banks of the stream remaining intact as well as the higher parts of the valley to the west.

Two erosion systems can be distinguished:

- old stream channels of the Hezerwater, meandering from south to north through the pit;
- surface-water erosion gullies, running from the western slope of the plateau to the valley, approximately from west to east and perpendicular to the course of the Hezerwater, and relatively steep-sloped, with a measured maximum gradient of 23° (W-Gully).

Both systems yielded artefacts and bones: on the banks, in the stream base and occasionally in the channel fill. From the upper, drier parts of the valley, artefacts were also recovered from a number of sites.

Let us first consider the succession of interstadial and interglacial soils encountered at Veldwezelt-Hezerwater. These are presented in table 3, which shows the oldest soils at the bottom and youngest at the top. The soil names have a B at the end, tagged onto the name of the sediment on top of which they were formed

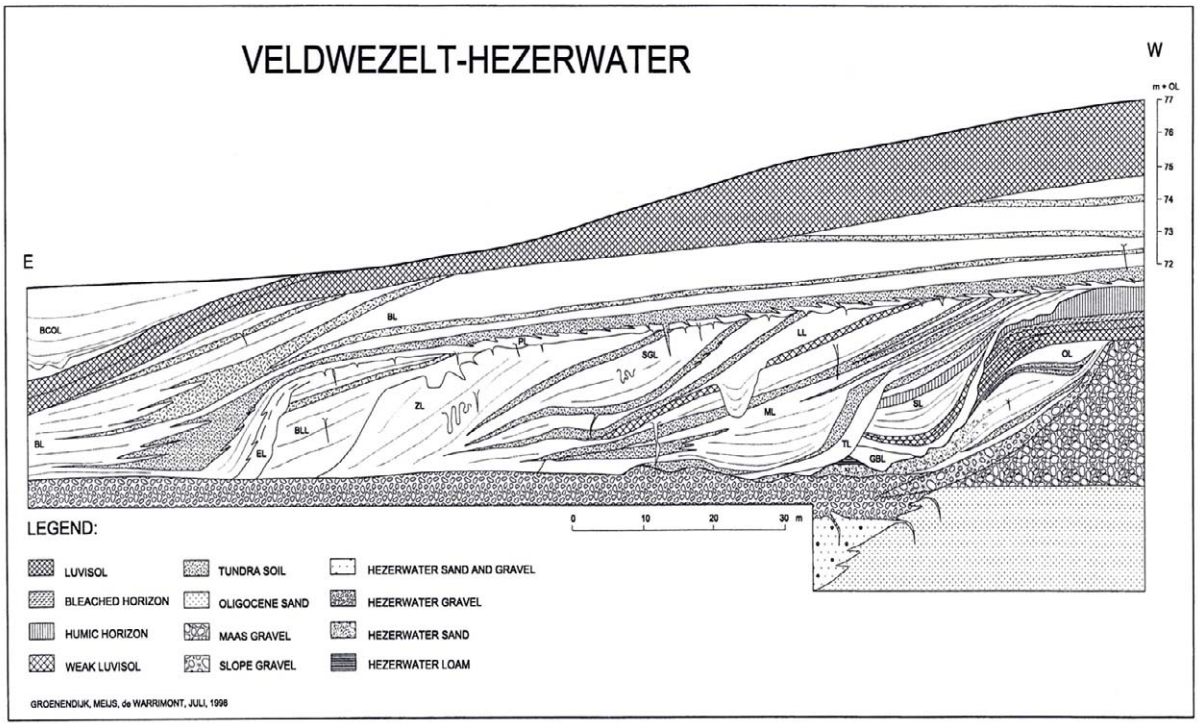

Figure 11. East-west soil profile through ancient channels of the Hezerwater brook at Veltwezelt-Hezerwater, with Saalian and Eemian deposits in the west and the main stadials of the Weichselian indicated by letters (see table 3). Figure by the author.

(according to the nomenclature of the same table). These sediments, deposited in the stadial prior to soil formation, are either wind-blown loess, or melt water or slope deposits associated with erosion. In most cases these soils were formed by synsedimentary processes (*i.e.* synchronous with sediment accumulation) under interstadial climatic conditions in which the landscape was increasingly vegetated or, alternatively, under circumstances in which sedimentation was delayed (see also Antoine *et al*., 2002). Also included in table 3, between brackets, are the names formerly given to the respective soils. For a detailed overview of the lithological, sedimentological and pedological description of the Veldwezelt-Hezerwater sequences, see Meijs, 2006a ('profile description: version 26 August 2006').

Sediment & soil names Veldwezelt-Hezerwater	**Short sediment description (according to Meijs, 2006a)**
74 Holocene	Luvisol
73 OCOL/BCOL	Two packets of colluvium (~7000 – 400 BP)
72	Erosion/gelicolluvium, **polygonal frost network**
71	Humic horizon
70 UBLB	Luvisol. 'Laacher See' tephra could be traced in the upper part
69 BL	Silt loam with **small frost cracks**
68 BBLB = BLB	Weak tundrasol
67 BL	Silt loam with **frost cracks up to 1 m**
66 MBLB	Weak tundrasol
65 BL	Silt loam, with **frost cracks and deep ice-wedge casts**
64 OBLB	(Humic) tundrasol
63 BL	Silt loam with **frost cracks**
62 *THB* = NB (*44*) Tongued horizon of Nagelbeek	Humic tundrasol complex. **Polygonal frost network and cryoturbation.**
61 *PL* (*43*)	Wind erosion/water erosion/strongly laminated silt loam above a **desert pavement**. **Large frost cracks and ice-wedge casts**

60 EL	Erosion/laminated silt loam with intercalated Eltville tephra
59 BLLB	(Weak) tundrasol
58 BLL	Erosion/laminated silt loam. **Some very deep frost cracks.**
57 *ZL* (*42*)	Strongly laminated silt loam. **Large convolutions, frost cracks and ice-wedge casts**
56 SGLB = N-3	Tundrasol
55 SGL	Laminated loess. **Some convolutions, frost cracks and ice-wedge casts.**
54 GLB = N-2	Tundrasol
53 GL	Laminated loess. **Some convolutions, frost cracks and ice-wedge casts.**
52 *LLBB* = N-1 (*41*)	Tundrasol
51 LL	Erosion/weakly laminated silt loam
50 LLOB = OK	Brown artic cambisol, decalcified
49 OLL	Laminated silt loam, with **deep ice-wedge casts and cryoturbations**
48 MLB = N0, *MLB4 (40)*	Grey-brown tundrasol, slightly decalcified
46/47 *MLMB* = N1, *MLB2, MLB3 (38, 39)*	Two tundrasols
45 *WFL* = N2, *MLOB, MLB1 (37)*	Tundrasol, with *in situ* artefacts
44 *ML (36)*	Laminated silt loam, **small frost cracks**
43 TLB = *TL-R, TL-GF, TL-W (35)*	Weak humic tundrasol, with *in situ* artefacts
42 TL = WG, *HWG2, W-G (34)*	Basal gravel and grit-bed/mud flows, with **frost cracks and cryoturbatic convolutions (30 cm)**
41 TSB = N3	Weak humic tundrasol
40 TSL	Humic-geli-colluvium/loess
39 *SLB* = N5 (*33*)	Humic-rankosol/cambisol
38 SL	Humic-geli-colluvium with **convolutions**
37 BB	Gray-brown arctic soil: soil complex with two subsoils (BB & OBB), with **frost cracks, strong cryoturbatic convolutions (30 cm) and ice-wedge casts**
36 *GBL = SL, MRW (32)*	Gritbed and gravel flow, with **strong cryoturbatic convolutions (30 cm)**
35 HL	Marker loess
34 *BHZB (31)*	Weak chernozem, with **a shallow polygonal frost network** on top
33 *MHZB (30)*	Weak humic rankosol
32 MGC	Geli-colluvium
31 MGF = *MB (29)*	Humic mud and gravel flow
30 OHZB = *OHZB1 & 2: 27 & 28)*	Chernozem. On top: charcoal and Rocourt tephra maximum.
29 RZ	Humic-rankosol, with **polygonal frost network**
28 *BHB (26)*	Geli-colluvium, with **deep polygonal frost network**
27 V*BLB (25)*	Luvisol, with *in situ* artefacts
26 *RHZB (24)*	Humic-rankosol
25 *RBHB (23)*	Geli-colluvium, with **polygonal frost network**
24 *RB (22)*	Luvisol
23 *OBHB (21)*	Geli-colluvium, with **polygonal frost network**
22 *PGB (20)*	Luvisol
21 *GSL (19) (Top GSL: OMVL)*	Geli-colluvium
20 *VLB (18)*	Humic-rankosol, with charcoal and *in situ* artefacts
19 *VLL (17) (reduced OVL)*	Geli-colluvium, with *in situ* artefacts
18 SVLB = *SRB (16)*	Luvisol
17 SVL = OL4 (*OL4A & B) (14 & 15)*	Laminated silt loam and tundrasols, with **cryoturbatic convolutions and ice-wedge casts**
16 SVG = *GRA1 (13)*	Basal gravel/gravel slump

15 UVL = ZN, *ZNB (12)*	Laminated silt loam and tundrasols, with *in situ* artifacts
14 UVG = *WV2, TDA, GRA0 (11)*	Basal gravel/gravel slump
13 WVLB = *HSB (10)*	Weak humic tundrasol
12 WVL = *OL3 (9)*	Laminated silt loam
11 WVG = *WV1, BDA (8)*	Basal gravel/slope fan
10 LS = *HSS, ZZ (7)*	Hezerwater Sands & Silts. Stratified loams and sands with **frost crack polygons**
10 *OL2 (7)*	Finely laminated sandy silt loam with **ice-wedge casts, deep frost cracks and cryoturbation**
9 *OL1 (6)*	Laminated silt loam with **small frost cracks**
8 *OLB (5)*	Tundrasol
8 OL	Homogeneous silt loam
7 GS-2 = *HG2 (4)*	Silty-gravelly slope deposit
6 GS-1 = *HG1 (3)*	Sandy-gravelly slope deposit
5 SG = *HWG1 (2)*	Sandy gravel: **cryoturbatic convolution with an amplitude of 1.5m**
4 *GC (1)*	Gravelly geli-colluvium
4 GF	Gravel flow
3 FS	Fluvial sand
2 MG	Maas gravel
1 TS	Tertiary sand

Table 3. Interstadial and interglacial soil succesion at Veldwezelt-Hezerwater, from old (bottom) to young (top), according to Meijs (2006a) and based on east-west profiles from 1995-1998 and north-south profiles from 2002-2006. The names used by the Veldwezelt-Hezerwater research team in the past are also given, while the sediment names used by Bringmans are italicized (Bringmans, 2006). The latter are based on north-south profiles in the west of the quarry, where the main archaeological sites were excavated. Evidence of periglacial phenomena is reported in bold typeface, while the principal erosional phases are indicated in bold.

4.2. Archaeological sites

This section describes the principal archaeological sites discovered by the present author in the Veldwezelt-Hezerwater quarry between 1995 and 1999 as a result of intensive prospecting activities there. There were major differences between the various sites and in the composition of the sediments from which the finds were recovered, with some of them primary, *in situ* sites and others *ex situ*, *i.e.* with artefacts and faunal remains in a secondary context. The numerous secondary context sites are not discussed in the present paper; for these the reader is referred to Bringmans (2006). The primary context sites with artefacts and macrofaunal remains discussed here were all recovered from sediments weathered and homogenised by soil formation, presumed to have been formed under mild, interstadial conditions, during which there was an increase in vegetation cover and a decrease in sedimentation. These soils were synsedimentarily formed, homogenised through bioactivity and modified by physico-chemical weathering. These sites were not located in unweathered sediments associated with stadials (cold episodes), *e.g.* sequences of eolian loess, stratified melt water deposits or deposits resulting from soil erosion (geli- or solifluction), which also often show evidence of periglacial phenomena in the form of ice-wedge casts, frost cracks and cryoturbations.

Below follows a detailed description of the chronostratigraphic sequence unravelled in the Veldwezelt-Hezerwater quarry and the main primary context archaeological sites. These have been correlated with the geologic profiles, as surveyed by Groenendijk, Meijs and the present author between 1995 and 1998 (figures 11 & 14).

Primary context archaeological sites in the wetter parts of the Hezerwater valley

UBLB

At the eastern end of the quarry, in 1998 a soil was exposed on the top of the Late Weichselian loess and below the phase of Holocene soil formation. This soil, a Luvisol (Meijs, 2006a), is the Allerød soil (figure 12). In a fairly flat section of the terrain, a cm-thick, circular layer of charcoal one m in diameter was found in the humic horizon of this soil (figures 12 & 13). Despite an intensive search, no Upper Palaeolithic stone artefacts were found. From this observation alone it is unclear whether the charcoal is to be associated with human occupation. It is a potential trace of human presence here during the Allerød Interstadial.

Figure 12. In 1998, at the eastern end of the loess wall in the Veldwezelt-Hezerwater quarry, the Allerød soil was exposed. The origin of the sacciform soil disturbance is not yet understood. Photograph by the author.

Figure 13. A cm-thick circular layer of charcoal, one metre in diameter, in the humic horizon of the Allerød soil at Veldwezelt-Hezerwater. Photograph by the author.

TL channel

The TL channel, dating from the Weichselien and yielding artefacts in the TLB horizon at Sites TL-R (discovered on December 19, 1998), TL-GF (April 25, 1999) and TL-W (September 3, 1999), meanders through the pit, running approximately from south to north. It is considered to be a fossil channel of the Hezerwater. At these three sites, archaeological surveys were carried out on the west bank, yielding the first artefact on 22-11-1995. The typology and technology of the TL artefacts, their fresh appearance and the quality and homogeneity of the flint all point to these sites on the west bank of the fossil Hezerwater being primary-context sites left behind after the valley was eroded and gravel deposited. From the faunal remains recovered from the archaeological sites of the TLB horizon, the following five species have been identified: horse, Bos/Bison, reindeer, mole (*Talpa*) and water vole (*Arvicola*) (internal report Cordy, 16 May 2003). These are low-density sites. In the Maastricht-Belvédére quarry, the low-density sites were likewise found in the wetter parts of the river valley (Vandenberghe, 1995). On the higher, drier parts of the valley investigated there, a number of flint knapping sites were found, and at the southern end of the VBLB Site at Veldwezelt-Hezerwater (see below) one such location was also found.

The artefacts recovered from the sites on the banks of the TL channel were large, far larger on average than those found at the other sites in the Veldwezelt-Hezerwater quarry. They are often made of excellent-quality Lanaye flint. A relatively high proportion of the artefacts is retouched, as is often characteristic of low-density sites (Gamble, 1999). In typological terms there is an affinity with the Quina Mousterian (Bringmans *et al.*, 2006); this is also the case with the finds from Site WFL (see below), to which a younger date has been assigned.

Site TL-W

This site, investigated from April 2002 onwards in the south-west of the Veldwezelt-Hezerwater quarry, is part of the meandering TL channel, which had first been described and drawn in 1996 from an exposure about 150 m to the north. The artefacts on the edge of the west bank were in the same stratigraphic position as those recovered from the other, aforementioned TL sites. From 1996 onwards, it was possible to follow the course of the somewhat meandering river channel back to this point.

From the minimal vertical spread of the artefacts, which follow the base of the TLB loess in the TL channel, their horizontal orientation, their fresh appearance and the lack of any significant patina it was concluded that the flint artefacts on top of the river gravel were situated in a primary context. Besides regional Lanaye flint, this level also contains Haspengouw flint procured from further away (Bringmans, 2006). This site is older than Site WFL. The first TL-W artefact was recovered from a trial pit (excavation plot 39N-127E) excavated at Site WFL in 1999, one m below the weak reddish-brown WFL horizon (see below).

That there were few refits in the low-density sites TL and WFL, where, in contrast to the VBLB (see below), little flint knapping took place, is hardly surprising. It need not be evidence of a non-primary context for the sites. In typological terms, the sites are homogeneous. As far as raw materials are concerned, the artefacts from the TL sites appear to be from a limited number of Raw Material Units (RMUs). At TL-W some of the flint is of the Haspengouw variety, but the majority is high-quality Lanaye flint procured regionally. Besides Lanaye flint, Site WFL yielded more Haspengouw flint. One of the artefacts found was made of Wommersom quartzite, the natural provenance of which is some 50 km west of the Veldwezelt-Hezerwater quarry.

VLB gully, north bank

This was an erosion gully running west-east and, according to Gullentops (Bringmans, 2006: 91), fed by springs, forming an 'amphitheatre'. The gully slopes from west to east at a gradient of about 6 degrees. Here the artefacts were recovered from the homogeneous loam in the incipient gully infill, which was locally more than 10 cm above the grit bed of the VLB in a horizon with numerous charcoal fragments as well as a dense concentration of charcoal about one m wide. Refitting of the artefacts found here indicated that a major proportion of the finds were still in a primary context position. The artefacts lay in the upper half of the humic VLB soil. On the north bank of the gully, below the VLB erosion horizon, was a second archaeological level: VLL, associated with an older erosion-sedimentation cycle. Here, too, there were good reasons for assuming a primary context for the artefacts, on the following evidence, in both cases: refitting sequences in close proximity, the fresh appearance of the artefacts, the presence of charcoal concentrations (VLB), the homogeneous composition of the loam, the - in general - non-Levallois typology, the small size of the cores, and the use of poor-quality flint procured locally. There was nothing to indicate that the artefacts had been flushed together. Site VLB was discovered on May 1, 1998 and Site VLL on May 20, 1998.

VLB gully, south bank

The artefacts were found on the south flank of the U-shaped VLB gully. In this case they were recovered from the vicinity of the VLB grit bed. The gradient of the south bank is also fairly steep: about 12 degrees. By careful scraping of the exposed pit wall, this line of stones could be tracked for a fair distance. Although the density of gravel was low, it was a convincing erosion surface. The artefacts were located in a zone about 10 cm thick around this line. The stone line was overlain by the light humic soil and underlain by a bleached horizon, below which was a ferruginous horizon coloured slightly red. Artefact refitting indicated a primary context for most of the finds. From this archaeological horizon numerous charcoal fragments were also recovered, some of them in concentrations, with unusual markings visible in the substrate. The significance of these markings is unclear, but they are probably of anthropogenic origin, as discussed below (De Warrimont, 2004).

Intermezzo

The following lines of evidence point to all the sites in the VLB gully dating to an interstadial at the end of the Saalian (OIS6):

- The VLB artefacts were in a feeble humic soil, a humic-rankosol younger than the Hezerwater Sands & Silts (LS/*HSS*), and older than the PGB - the Eemian soil - overlying them.
- The Hezerwater Sands & Silts are the youngest deposits showing clear evidence of intense cold below the Eemian soil, with ice-wedge casts, deep frost cracks and cryoturbations. On these grounds, they were correlated with a stadial in OIS 6.
- In the nearby Belvédère pit, the final cold spell of the Saalian can be observed between the Belvédère interglacial complex (OIS 7) and the 'Rocourt soil' (see below) as a highly cryoturbated gley horizon (De Warrimont, 2002b).
- Between the VLB soil and the PGB - the Eemian soil *s.s.* - lies stratified colluvium, the GSL. In the GSL, no periglacial phenomena associated with pre-Eemian cold episodes are to be observed. The colluvium between the soil formation of the VLB and PGB indicates an open landscape at the time of sedimentation, with a deteriorating climate.
- The charcoal from the VLB soil is pine (*Pinus*). No charcoal from deciduous trees was found, indicating that we are here concerned with an interstadial.
- The presence of artefacts in a primary context is evidence of a climate favourable enough for human occupation; this is unlikely to have been a stadial.
- The soil most resembles the humic soil found at the east end of the Veldwezelt-Hezerwater quarry, a Luvisol-like soil exposed there in 1998. This has been correlated with the Allerød Interstadial (Schirmer, 2000: 40). Here, too, the same tripartite division was found, comprising, from top to bottom, a humic soil, a bleached horizon and a ferruginous horizon (figure 12). This interstadial also represents an incipient rise in temperature presaging the next interglacial.
- The heavy-mineral composition of the OL loess in the north of the pit, overlying the Hezerwater Sands & Silts, corresponds with that of the late-Saalian loess found in various exposures studied in the vicinity of the Veldwezelt-Hezerwater quarry (Meijs, 2002).

In summary, all this evidence points to the VLB representing an interstadial between the final intense cold of the Saalian and the start of the Eemian Interglacial. The Zeifen Interstadial (Seidenkrantz *et al.*, 1996) would appear to be a good candidate. This is interstadial OIS 6.01, the final interstadial of OIS 6, the Saalian, and dates to around 135 ka.

ZNB sites

At the top of a half-m-thick layer of grey clay loam devoid of stones, in 1996 a large flint backed-knife was found (discovered on June 28, 1996). Several metres away, in the same layer, two more artefacts were discovered. None of the artefacts was eroded. The loam layer was on top of the Hezerwater Sands & Silts and was eroded at the end of the Eemian *s.l.*, after which the Grit Bed Layers (GBL) were deposited along with lumps of humic soil with traces of enstatite-containing tephra. In 1998 this ZNB horizon was again found, in the clay loam underlying the grid bed beneath the central section of the VLB channel. When this layer became the focus of archaeological investigations in 2002, it was given the local name GRA, in reference to gravel. This was because here, in thin layers of gravel over- and underlying the loam, artefacts were also found which, given their clearly eroded surfaces, were assumed to have been transported by water (Bringmans *et al.*, 2002a).

The four artefacts recovered from the loam show no such signs of erosion. These artefacts' provenance in the loam layer, together with their fresh appearance, suggest that as far as the ZNB unit is concerned we here have a primary archaeological context. This loam is underlain by the Hezerwater Sands & Silts and overlain by the VLB grid bed and in contrast to the Hezerwater Sands & Silts beneath it, this ZNB loam no longer shows any evidence of severe cold, in the form of ice-wedge casts, frost cracks or cryoturbations. In chronostratigraphic terms, these finds are allied to those from the VLB grid bed, the VLL and the VLB above it, of which the latter correlates with the Zeifen Interstadial at the end of OIS 6.

Primary context archaeological sites in drier parts of the Hezerwater valley

Site VBLB

This site - discovered on October 31, 1997 - is located somewhat higher up the side of the Hezerwater valley. It comprises two zones: a knapping area lower down the valley slope to the south and an activity area further uphill with larger artefacts, including retouched tools. Many of the artefacts are from a single RMU. Several refits, the presence of charcoal, the homogeneity of the finds and the interglacial soil from which they were recovered indicate a primary-context site. The valley side slopes to the south-east at a gradient of about five degrees.

The finds were recovered from the VBLB soil (this horizon and archaeological site were formerly denoted by the letters VBL), a Luvisol (Meijs, 2006a) or grey forest soil (Greyzem, *sensu* Antoine *et al.*, 2002; Haesaerts & Mestdagh, 2002), the uppermost of a complex of three interglacial soils (Ickinger & Schirmer, 2002: 11, 59). The aforementioned Rocourt soil is at the bottom, the VBLB on top. Remnants of fossil soils, erosion horizons, bleached zones, humic horizons and three levels with desiccation or frost cracks in the profile on the south-west side of Site VBLB support this tripartite division of the Rocourt soil complex (figure 14). The same threefold division can also be observed in the nearby quarry Kesselt-Op de Schans, where two refit sequences (comprising seven and ten flint flakes, respectively) were recovered within a small area (~ seven m^2) in the VBLB soil, in the same stratigraphic position as at Veldwezelt-Hezerwater (figure 15). They show the same recurrent Levallois technology observed at Site VBLB.

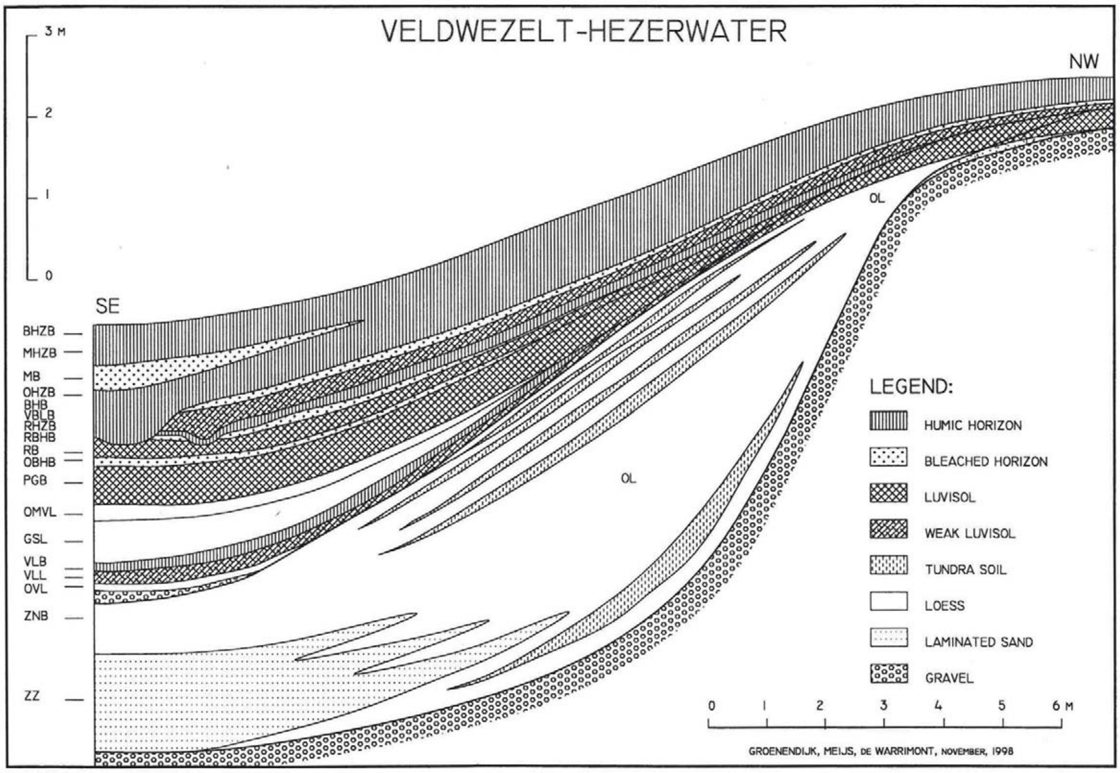

Figure 14. Rocourt soil complex and humic soil complex above the Hezerwater Sands and Silts (ZZ) at Veldwezelt-Hezerwater (see table 3). Figure by the author.

At Garzweiler (GE) (Schirmer, 2000; Ickinger & Schirmer, 2002: 59) and in northwestern France (Antoine *et al*., 1998, 2002) this same tripartite division of the Eemian Interglacial *s.l.* can also be observed with, moreover, the same characteristic threefold division of the humic soils seen overlying the Rocourt soil complex in the Veldwezelt-Hezerwater quarry (figure 14). They correlate the three soils of the Rocourt soil complex with OIS 5e, 5c and 5a (but see, for an alternative: Haesaerts & Mestdagh, 2000). The humic zones are posited in interstadials 20 and 19 of the Greenland ice core (GRIP2) climate sequence (Antoine *et al*., 2002: 81). The VBLB soil in which the artefacts were found is the topmost of the three Luvisol units that make up the Rocourt soil complex. This was formed prior to the incipient cold at the end of the Eemian Interglacial complex. It is proposed that Site VBLB should be correlated with OIS 5a.

Figure 15. The Site VBLB in the Veldwezelt-Hezerwater quarry during the 1998 archaeological campaign. The artefacts were found in the reddish soil (VBLB) below the bleached horizon (BHB), which forms the transition between the Rocourt soil complex and the humic soils overlying this profile (right foregound). Photograph by the author.

Site WFL

The archaeological Site WFL was discovered on June 17, 1999 on a loess slope at the south-west end of the Veldwezelt-Hezerwater quarry. The artefacts and rich faunal assemblage of the WFL were recovered from a layer of reddish-brown weakly calcareous loess nowhere thicker than 10 to 15 cm. This is a weak soil (incipient *Braunerde* or humic tundrasol), partially decalcified and with the upper moiety homogenised. The stratigraphic position of the soil fits in well with the reference profile elaborated in 1998 (Gullentops *et al*., 1998)

To validate the stratigraphy of Site WFL, in 1999 a pit was dug cutting through the archaeological horizon. It was anticipated that the WFL would be underlain by the TLB loess. This indeed proved to be the case, and once more an artefact was discovered. Starting in April 2002, to the south of WFL Site the TL channel was partly excavated, using a shovel. Here, too, artefacts were uncovered in the TLB.

Besides artefacts, the WFL also yielded micro- and macrofaunal remains. Taken together, the limited vertical spread of the finds from Site WFL, the characteristic soil-formation features, the wealth of finds, the typology, technology and material of the artefacts, several refits, and the situation within the landscape are evidence of a primary-context site.

The presence of a fossil hyena den in the vicinity of this site, identified on the basis of recovered faunal remains (Cordy, 2002), the presence of hyena and lion among this assemblage and carnivore gnaw marks on the bones indicate that hominids were not the only carnivores to have had an impact on the rich fauna with which this region was endowed.

4.3. The chronostratigraphic framework of the Weichselian archaeological sites WFL and TLB

The extensive soil sequence observed in the Veldwezelt-Hezerwater quarry contains several horizons that show evidence of extreme cold (table 3). The three oldest of these zones are:

- in and below the Hezerwater Sands & Silts (LS/*HSS*), the bottommost of the deposits exposed by quarrying activity in the Veldwezelt-Hezerwater quarry;
- the stratified loam around the grey-brown arctic soil (BB), which can be stratigraphically positioned after the first strong erosion phase following the Eemian *s.l.* and prior to the TLB, and is thus younger than the OHZB with the Rocourt tephra, the enstatite-containing humic zone;
- the zone containing large ice-wedge casts, located above the ML soils and thus younger than the WFL.

Between the ML soils and the loess containing the Eltville tephra (EL: volcanic Tuff dated to *c*. 20 ka (Antoine *et al*., 2001: 226)) are another five soils, *viz*. the LLOB and four tundra soils (figure 11 & table 3). This younger loess has large ice-wedge casts and cryoturbations. The faunal assemblage in these deposits and the declining number of crotovinas (animal burrows filled with material from a different horizon) indicate a progressive cooling of the climate. It is also the end of human occupation - there are no longer any artefact concentrations to be found.

The faunas recovered from the TLB and WFL and from the bottommost ML soils are evidence of mild interstadials, with mole and badger (WFL) present - burrowing species that cannot withstand extremes of cold.

Numerous high-resolution climate sequences from continental Europe, for example from the Velay crater lakes (Massif Central, F) and from Grande Pile (Vosges, F), as well as from the deep oceans (Pisias *et al*., 1984) and the Greenland and Antarctic ice (GRIP & GISP2 records, respectively Dome C - CH_4 and Vostok - δD: Blunier & Brook, 2001; Peterson *et al*., 2000; Indermühle *et al*., 2000; Spahni *et al*., 2005; Martrat *et al*., 2007; Jouzel *et al*., 2007) provide clear evidence of four pronounced interstadials in OIS 3, between c. 26 and 61 ka, alongside numerous temperature oscillations of shorter duration. The interstadials between 48 and 61 ka were particularly mild. In Grande Pile and Twente (NL) the coldest stadial of OIS 3 is the Hasselo Stadial (Ran & Van Huissteden, 1990), dated to around 47 ka (based on calibrated ages, see: Genty *et al*., 2003; Van Andel, 2004). In Twente this coincides with a stratigraphic phase containing numerous ice wedges. This is followed by two, younger interstadials: the Hengelo Interstadial (c. 44 ka) and the Denekamp Interstadial complex (c. 32 to 37 ka), the latter of which is interrupted by two mild stadials of brief duration. The high-resolution deuterium curve from Vostok, Antarctica, which provides a good indication of approximate global temperature, also shows evidence of a significant temperature minimum between A2 and A3, in the Middle Pleniglacial at around 47 ka.

In Twente and Grande Pile (Ran & Van Huisssteden, 1990; Woillard & Mook, 1982) there is also evidence of the Moershoofd Interstadial 'complex', predating 47 ka. In the Veldwezelt-Hezerwater quarry the Rocourt soil complex, dating from the Eemian *s.l.* (OIS 5), and the periglacial phenomena in the deposits from the Saalian and Weichselian permit correlation of the numerous soils exposed here with other high-resolution climate sequences.

The following correlations are proposed:

- the Hezerwater Sands & Silts (LS/*HSS*) with OIS6;
- the soils of the Rocourt soil complex with the OIS 5 climate sequence;
- the cryoturbated loess layers around the BB soil with OIS 4;
- the large ice-wedge casts in OLL, overlying the ML soils, with the Hasselo Stadial, in OIS 3.

Working on these assumptions, the soils from the Veldwezelt-Hezerwater quarry were then correlated in greater detail with other high-resolution sequences (table 4), thereby making the following, additional assumptions:

- the relatively weak periglacial phenomena in the Meltwater Loams (ML) correlate with the weak stadial in the Moershoofd Interglacial complex;
- the cluster of three tundra soils above the decalcified, brown LLOB correlates with the Denekamp Interstadial complex.

Place	OIS 3 Middle Pleniglacial							OIS4 Early Pleniglacial			OIS5
										Early Glacial	
Twente, Dinkel valley	Denekamp Interstadial complex		Hengelo	H A S S E L O	Moershoofd Interstadial complex	Lattrop Interval					
V19-29	3.1		3.13		3.3		3.31			5.01	5.03
Greenland GISP2	5-8		12		14-15		16-17		18	19	20
Antarctica	A1		A2		A3		A4			A5	A6
Grande Pile	16 Grand Bois		15 Charbon		14 Pile		13 Goulotte		11 Ognon III	10 Ognon II	9 Ognon I
Veldwezelt-Hezerwater	SGLB GLB LLBB	LL	LLOB	OLL	WFL/MLMB ML TLB	TL	TSB TSL SLB	SL OBB/BB		MHZB/BHZB MGF/MGC OHZB	
Estimated absolute age [ka] (Genty *et al.*, 2003)	32-37	39	43-46	47	48-55	56	57-61	61-68		70	73

Table 4. Main stadials and interstadials in the Middle Weichselian according to authoritative high-resolution climate sequences, with estimated absolute age (data from: Woillard, 1978; Woillard & Mook, 1982; Pisias et al.*, 1984; Ran & Huissteden, 1990; Blunier & Brook, 2001; Genty* et al.*, 2003).*

On these assumptions, the archaeological sites TLB and WFL are to be correlated with the Moershoofd Interstadial complex, *i.e.* the second part of the mild first half of the Middle Pleniglacial: OIS 3, between c. 48 and 55 ka. This correlation is supported by the uncalibrated ^{14}C date of animal bones recovered from the WFL Site of ^{14}C = 45.44 ka +4450/-2850 BP (Bringmans, 2006a: 319), coinciding with the end of the Moershoofd Interstadial complex. Correction (Mellars, 2006: 91) then yields c. 48 ka (= 45.5 + 2.5 ka) as the most probable age of the WFL Site.

The tripartite division of the Denekamp Interstadial complex is also observed in Twente (Ran & Van Huissteden, 1990) and Grande Pile (Woillard, 1978), as well as in Schwalbenberg (GE), where the three Sinziger soils have been correlated with Denekamp (Schirmer, 2000). The Reisberg soil from this latter site has been correlated with OIS 4 and is thus equivalent to the forest soil BB in the Veldwezelt-Hezerwater quarry. On closer inspection, the GRIP2 high-resolution climate sequence from the Greenland ice even shows a cluster of four warmer stages at around 35 ka, the oldest of which is the warmest. The two temperature peaks in the middle are interrupted by a relatively weak and brief period of cooling. In the field this might all well be observed as a single layer of loess, leading to the aforementioned tripartite division. Of these three tundra soils in the Veldwezelt-Hezerwater quarry, the middle one (GLB) was clearly divided into two subsoils (two grey gleyed horizons separated by ten cm of yellow loess), thus even providing local evidence of the fourfold division reflected in the Greenland (GRIP2) sequence.

After the Denekamp Interstadial complex the climate becomes considerably colder. In the Veldwezelt-Hezerwater quarry this cooling is reflected in the ZL and BLL loess, which shows numerous traces of intense cold, marking the transition to glacial stage OIS 2.

The continental soil sequence in the Veldwezelt-Hezerwater quarry is of an unparalleled completeness, its stratigraphy fully congruent with the climate sequence evidenced in the records of the deep ocean (Peterson *et al.*, 2000) and polar ice. There is good correlation, moreover, with the most detailed continental soil sequences currently available from northern Europe, such as that from Grande Pile, as well as the Rhineland soil sequence published by Schirmer (2000), which combines profiles from two different exposures: Langweiler 4 and Schwalbenberg. Using the high-resolution Greenland climate curve (GRIP2), it is even possible to refine the above scheme still further. The results of such an exercise are shown in table 5. Besides the interstadial and interglacial soils reflecting warmer stages, this complete stratigraphic overview is also based on features associated with cold periods, such as erosion surfaces and zones with periglacial features in the form of cryoturbations, ice-wedge casts, frost cracks, thermokarst and desiccation polygons (table 3).

The interstadials 3, 9, 10 and 11 observed in the GRIP2 sequence are lacking in the Veldwezelt-Hezerwater sequence (table 5). In these weakly developed, short-lived interstadials it is quite possible that no clearly visible soil was formed. In Twente and Grande Pile the interstadials 9, 10 and 11 between Hengelo and Denekamp are likewise absent.

4.4. The Weichselian fauna

Between 1995 and 2003 the bones of several species of large mammal (*e.g.* figure 16) were recovered from a number of horizons (Bringmans *et al.*, 1999/2000; Bringmans, 2006: 281-284), as well as smaller, rodent bones. The provenance of the micro- and macrofauna is summarised in table 6. Only some of these microfaunas have yet been analysed by Cordy, with bones of the arctic lemming (*Dicrostonyx torquatus*) identified in the BLL and between the BBLB and MBLB, for example, *i.e.* in sediments dated to OIS 2 (internal report Cordy, 9 April 1998). The calcareous Weichselian loess yielded a wealth of fauna, particularly from the Middle Pleniglacial, OIS 3. It would appear that the large mammals left this landscape quite some time before many of the rodents - and along with the large mammals went the human occupants (De Warrimont, 2003c). With respect to the glacial stages, few faunal remains were found in the non-calcareous loess of OIS 4 (only two small mammoth molar fragments in GBL), while in the OIS 2 loess such remains were relatively few compared with OIS 3. In the Eemian soils, no fauna at all was found, a consequence of soil formation during the Eemian *s.l*, which led to decalcification of the soil matrix.

4.5. Conclusions

The Veldwezelt-Hezerwater quarry provides a high-resolution climate record that is exceptional for continental Europe. The extraordinary degree of correlation with the high-resolution climate sequences provided by deep ocean and polar ice records seems to show that the soil profile correlating with all the stadials/glacials and interstadials/interglacials of the late Saalian, the Eemian and the Weichselian is present almost in its entirety. This unique quarry has yielded six Middle Palaeolithic horizons in their primary context, of which the oldest

Weichselian subphases			Greenland – GRIP2 Interstadials	Veldwezelt-Hezerwater Interstadial	Stadial
OIS 2	Late Pleni-glacial	Bølling/Allerød	1	UBLB	
					BL
				BBLB	
					BL
				MBLB	
					BL
				OBLB	
					BL
		Nagelbeek horizon	2	THB	
		Eltville tephra			PL EL
			3		
			4	BLLB	
					BLL ZL
OIS 3	Middle Pleni-glacial	Denekamp Interstadial Complex	5	SGLB	
					SGL
			6	GLB	
					GL
			7	GLB	
					GL
			8	LLBB	
					LL
			9		
			10		
			11		
					LL
		Hengelo	12	LLOB	
		Hasselo			OLL
		Moershoofd Interstadial Complex	13	MLB	
					ML
			14	WFL/MLMB	
					ML
			15	TLB	
		Lattrop Interval			TL
			16	TSB	
					TSL
			17	SLB	
OIS 4	Early Pleni-glacial	Glacial			SL
			18	BB	
					GBL
OIS 5	Early Glacial	Rocourt tephra	19	MHZB/BHZB	
					MGF/MGC
			20	OHZB	

Table 5. Correlation of high-resolution Greenland-GRIP2 and Hezerwater climate sequences for the Weichselian Pleniglacial, based on occurrence of interstadial soils, erosion horizons and zones with periglacial phenomena. Archaeological horizons with primary context sites are coloured grey.

Figure 16. Macrofauna, including horse and rhinoceros, from Veldwezelt-Hezerwater site WFL. Photograph by the author.

three (ZNB; VLL; VLB) date from the late Saalian (OIS 6 and OIS 6.01). In addition, there is one archaeological horizon VBLB (OIS 5a) from the Early Weichselian (= Eemian *s.l.*) and two from the Middle Weichselian (TLB and WFL), associated with the Moershoofd Interstadial complex. All the horizons with primary context artefacts are homogenised soils formed by biogenic and other soil-forming processes during mild interstadials. The archaeological finds recovered during the excavations in this quarry between 1995 and 2004 have been analysed and discussed *in extenso* by Bringmans (2006).

From the calciferous loess, deposited in numerous layers in the course of the Weichselian, a rich microfauna was recovered, which has as yet been only partially analysed by Cordy. That analysis may provide new insight into climatic developments during the Weichselian and into the behaviour and environment of the Neanderthalers who evidently visited the landscapes of this part of northwest Europe, and more specifically the Hezerwater valley, a corridor between the Haspengouw and the north-south oriented valley of the river Maas, both of which were rich in raw materials of interest to human occupants. The Hezerwater valley was a sediment trap for the loess blown in by the wind during cold stages of the glacial cycle (De Warrimont, 2002a), at which time sediment was also being deposited by the brook. As a result, and thanks to the continual shift of the brook from west to east over the last 150 ka, an exceptionally rich soil profile from this period has remained intact for us to study.

For a period of ten years the walls exposed in the Veldwezelt-Hezerwater quarry have been intensively studied, as have those exposed in several other brickyard pits in the nearby vicinity, including the Maastricht-Belvédère quarry and the Kesselt-Nelissen quarry. Thanks to this intensive prospecting, it is also possible to draw conclusions from the *absence* of archaeological finds within certain strata. In layers with cryogenic phenomena, representing the stadials, the coldest stages of the glacial cycle, there are no primary context sites to be found, for example. The same holds for the PGB, the soil correlating with the Eemian interglacial *s.s.* (OIS 5e) and which is likewise characterised by an absence of artefacts, not even at the top of this soil in places where it has been truncated by erosional processes. Nowhere in any of the pits in the entire surrounding area have any such archaeological finds been made. Further south, in northwest France (Antoine *et al.*, 2003), artefacts have been recovered, but not in the region discussed here.

The decade-long study of the Veldwezelt-Hezerwater quarry forms a complement to the extensive studies carried out at the Maastricht-Belvédère quarry. Taken together, the research at these two quarries provides a detailed picture of Middle Palaeolithic occupation around the Maas, Jeker and Hezerwater valley and helps deepen our understanding of Middle Palaeolithic life in the loess landscape to the north of the Ardennes, where until 1980 knowledge of valley sites had been almost entirely lacking (Groenendijk & De Warrimont, 1995). In the interglacial and interstadial soils exposed in the Veldwezelt-Hezerwater and Maastricht-Belvédère quarries, those containing the greatest concentrations of macrofaunal remains - comprising several individuals and multiple large mammal species - artefacts were also consistently found, even when the faunal assemblage included carnivores (WFL). This supports the hypothesis that it was to a large extent our human predecessors that were responsible for the faunal concentrations recovered, *viz.* at Sites TLB and WFL at Veldwezelt-Hezerwater and Sites B, C, G and N at Maastricht-Belvédère.

Weichselian subphases			Fauna micro	Fauna macro	Veldwezelt-Hezerwater Interstadial	Veldwezelt-Hezerwater Stadial
OIS 2	Late Pleni-glacial	Bølling/Allerød			UBLB	
						BL
					BBLB	
						BL
					MBLB	
						BL
					OBLB	
						BL
		Nagelbeek horizon			THB	
						PL
		Eltville tephra				EL
						BLL
					BLLB	
						BLL
						ZL
OIS 3	Middle Pleni-glacial	Denekamp Interstadial Complex			SGLB	
						SGL
					GLB	
						GL
					LLBB	
						LL
		Hengelo			LLOB	
		Hasselo				OLL
		Moershoofd Interstadial Complex			MLB	
						ML
					WFL/MLMB	
						ML
		----------------------------			TLB	
		Lattrop Interval				TL
					TSB	
						TSL
					SLB	
OIS 4	Early Pleni-glacial				SL	
					OBB/BB	
					GBL	

Table 6. Weichselian soil sequence at Veldwezelt-Hezerwater, with zones yielding fauna coloured grey. Only horizons yielding a primary context fauna are shown, with faunas from erosion horizons of ambiguous provenance ignored.

5. Kesselt-Op de Schans: the chronostratigraphic framework

The Kesselt-Op de Schans brickyard quarry is just over one km south of Veldwezelt-Hezerwater, in the parish of Kesselt (former municipality of Veldwezelt [Belgium]) between the Albert Canal and the Dutch border (figure 1). After terminating its loam quarrying operations at Veldwezelt-Hezerwater, the firm Vandersanden Steenfabrieken moved on to Kesselt-Op de Schans, where the first archaeological primary context site was discovered in November 2001 by Groenendijk, in the VBLB horizon of the Rocourt Interglacial complex (primary context Site 1). An extensive survey of the loess stratigraphy was carried out by Meijs (Gullentops &

Meijs, 2002; Meijs, 2006b). In this quarry four Pleistocene interglacial soil complexes are exposed, considered to span the last 425,000 years: the Rocourt soil (MIS 5), Hees soil (MIS 7), Montenaken soil (MIS 9) and Pottenberg soil (MIS 11) (Meijs, 2002). More recently, on 5 June 2006, the present author discovered a new archaeological primary context site (primary context Site 2) in the Montenaken interglacial soil complex (figure 17). This site is now being excavated under the overall supervision of Van Peer (Catholic University of Leuven), with Van Baelen leading the work on-site. The loess stratigraphy of the quarry also continues to be investigated.

6. Results of the prospecting studies

This chapter presents some of the results of the prospecting work that have received little or no attention in earlier publications. During the many hours of geological and archaeological prospecting in numerous exposures of loess in Dutch and Belgian south Limburg since 1980 artefacts were found at various locations at varying depths. Most of the prospecting was carried out on the walls or bottoms of quarries where brickyard loam (loess) was being excavated, or in other major loess exposures, by carefully scraping the vertical walls and scrutinising them for phenomena of geological, pedological, palaeontological or archaeological significance. Among the fruits of this work were concentrations of flint artefacts in a non-primary context at several locations along the Albert Canal (*e.g.* Kesselt-Albert Canal: Lauwers, 1984; Lauwers & Meijs, 1985) while it was being widened, in a trench for a new gas pipeline at Voeren-Beekberg 2 (Belgium), in several cuttings created during road-works, in a number of brickyard quarries near Beek (The Netherlands), Schinnen (The Netherlands) and Romont (Belgium), and in several parts of the Kesselt-Nelissen quarry (Belgium).

Figure 17. Southern part of the Kesselt-Op de Schans quarry in June 2006. The bottom of the quarry is the top of the Montenaken soil. Photograph by the author.

In the course of these prospecting activities, artefacts still lying in a primary context were found in three different loess quarries: Maastricht-Belvédère, Veldwezelt-Hezerwater and Kesselt-Op de Schans. These quarries, all of which were operational at the time and which have since yielded multiple Pleistocene horizons with worked flint and other artefacts, were identified as being particularly suitable for long-term, intensive prospecting. By entering into collaboration with archaeologists and scientists from the universities of Leiden and Leuven, where staff, funding and research networks for multidisciplinary studies were available, a series of major archaeological excavations and ancillary studies could be undertaken.

In these quarries three types of archaeological sites can be distinguished. First, there are literally dozens of sites in a secondary context, *i.e.* displaced or disturbed by erosion, that have not been systematically studied, as well as a number of primary-context sites that did not permit further investigation. The second category are primary-context sites that could be comprehensively excavated over a larger area (5-765 m^2). This was the case at Maastricht-Belvédère Sites A, B, C, F, G, H, J, K and N, Veldwezelt-Hezerwater Sites ZNB, VLL, VLB, VBLB, TL and WFL and Kesselt-Op de Schans Site 2. Finally, there are sites, both primary- and secondary-context, where smaller-scale studies have been undertaken that have yielded important additional information. This was the case, for example, at Maastricht-Belvédère Sites D, E, L, M, O and Site N-Level X, Veldwezelt-Hezerwater Sites BDA, TDA, GRA, W-G and VBLB-S and Kesselt-Op de Schans Site 1 (VBLB horizon).

Thanks to the extensive surveys and studies carried out at the various quarries and the enormous array of observational data acquired it has been possible to build up a fairly comprehensive picture of the chronostratigrapy of these thick deposits, the topography of the palaeolandscape and the location of the archaeological sites in that landscape, as discussed at length above. Against this backdrop, we can draw a number of conclusions about the artefacts from the various archaeological levels as well as the significance of the macroscopic traces of fire and bones of large mammals discovered.

6.1. Chronological scheme

Based on the studies and surveys at Maastricht-Belvédère and Veldwezelt-Hezerwater and the results of the present study, figure 18 locates the phases of human occupation on a simplified temperature curve for the last 250,000 years. The dating of Site 2 in the Kesselt-Op de Schans quarry in OIS 9, not included in this figure, is still provisional and is based on the geostratigraphic survey carried out here by Meijs (www.archeogeolab.nl).

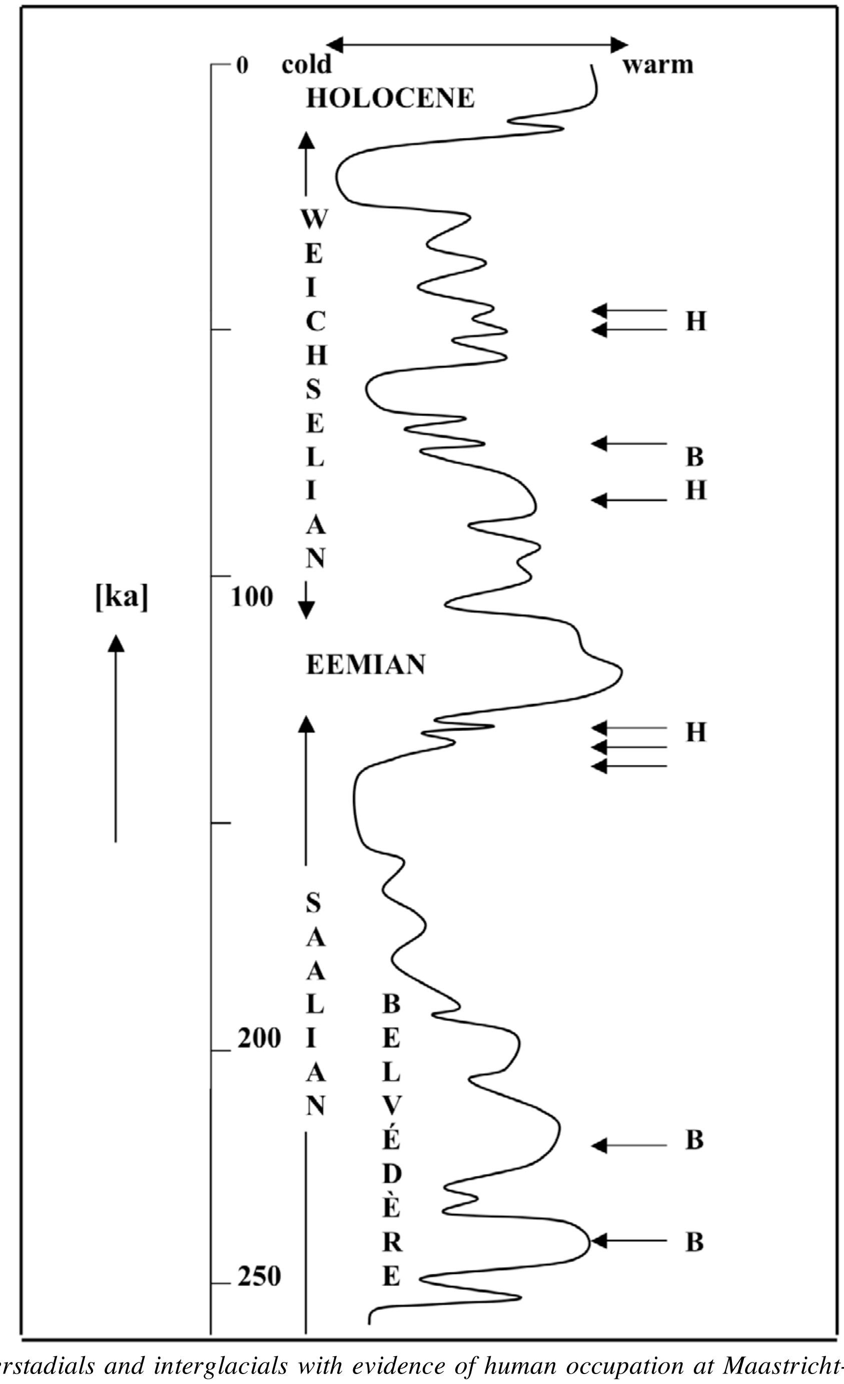

Figure 18. The interstadials and interglacials with evidence of human occupation at Maastricht-Belvédère (B) and Veldwezelt-Hezerwater (H), projected onto a simplified temperature curve. Figure by the author.

6.2. Archaeological sites: landscape setting and character

Over a period of 25 years an equal number of more or less well-studied archaeological sites have thus been excavated at these three quarries. This total, an average of one site a year, was determined mainly by the frequency with which such sites were discovered rather than the excavating capacity of the archaeological institutes. Compared with the vast number of hours spent prospecting here and the many thousands of square metres of vertical section scrutinised, this is a modest result. For years, these quarries were surveyed and investigated just about every week, and sometimes daily, by a small team of highly motivated enthusiasts.

Only occasionally did the archaeological find horizons yield artefacts in a primary context. Now and again, though, denser concentrations of worked flint were found. These sites are of two types: high-density and low-density, which differ in the character of their assemblages. The high-density sites, all of them in the Maastricht-Belvédère quarry and generally situated in the more elevated parts of the contemporary river valley, all show clear and extensive evidence of primary flaking of flint nodules. The picture to emerge from these well-researched sites (high- and low-density) is one of temporary (hours, days) camps or resting places where flint knapping and hunting-related activities took place. None of these sites has yielded any evidence of huts or other such structures, nor are the artefact densities such that they can be qualified as 'base camps', *i.e.* places where early humans gathered in larger groups for an extended period of time (weeks, months) or returned to repeatedly. What we can surmise, however, is that the palaeolandscape unearthed in the Maastricht-Belvédère and Veldwezelt-Hezerwater quarries was clearly very appealing to them, with its close proximity to a river or brook and a varied landscape providing firewood and other raw materials, fresh water, game to hunt and, occasionally, local flint.

The structures and details of these sites and the flint-knapping technologies evidenced there have been fairly extensively described (among others Roebroeks, 1988; Slanger, 1994; De Loecker, 2006; Bringmans, 2006). However, the bones of large mammals and remains of fire discovered at the various sites have received considerably less attention and their archaeological significance has not yet been considered in any depth (but see Stapert, 2007).

In the case of Maastricht-Belvédère Site N, the spatial distribution of the bones recovered was all but ignored, in contrast to the distribution of the flint artefacts found, shown here in figure 19 (Roebroeks, 1992: 7; Rensink *et al.*, 2006: 210). Table 7 lists the macrofaunal species recovered from the low-density Sites G en N. In figure 20 the locations of the remains (mainly teeth) of the three species of mammal recovered from Site N: horse (H), red deer (R) and Bos/bison (B), are projected onto the flint scatter. The correlation between the mammal remains and the main flint concentrations, *i.e.* zones with flint debitage and multiple tools, is such that we may assume that this fauna is not simply a 'background' fauna, but constitutes key evidence of major archaeological significance.

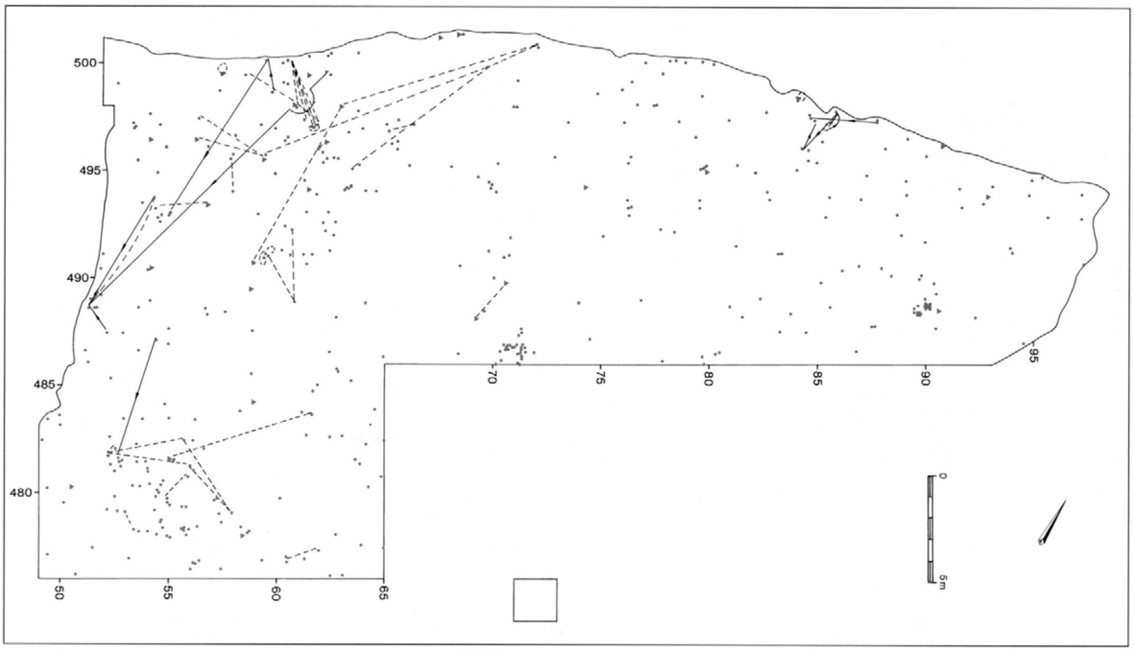

Figure 19. Artefact distribution and refit lines at Maastricht-Belvédère Site N. From: Roebroeks et al. *(1992).*

The stratigraphy of the artefact-bearing sediments and associated chronostratigraphy at Maastricht-Belvédère have not yet been published in sufficiently fine detail (De Warrimont, 2006b), leading De Loecker (2006: 230) to conclude that "[…] there are no reasons to assume that significant changes in raw material availability (amongst others distance to the flint and food sources, flint quality, etc.) had taken place during the relatively short period of assemblage formation". This conclusion is to be disputed, for a number of reasons. We are concerned here with the archaeological finds from Unit IV, dated to the Belvédére Interglacial, an interglacial complex within the Saalian. Not only does the geostratigraphy (see section 3 of this study) point to a different conclusion, but if we compare the technology of the flint artefacts from the two main archaeological levels of Unit IV (I = lower sites, II = upper sites), breaking these down into high-density (HD) and low-density (LD) sites (see table 8), we see a significant difference in technology between the two horizons.

Site	Unit IV level	Macrofauna	MNI	NIE
N	II	Horse	2	4
N	II	Red deer	1	7
N	II	Bos/Bison	1	2
G	I	Steppe rhinoceros	3	15
G	I	Red deer	2	10
G	I	Roe deer	2	8
G	I	Straight-tusked elephant	1	1
G	I	Bos/Bison	1	1

Table 7. Large mammal species from the low-density sites G and N at Maastricht-Belvédère. Note: MNI = minimum number of individuals; NIE = number of identified elements. '+' = present; '-' = not present.

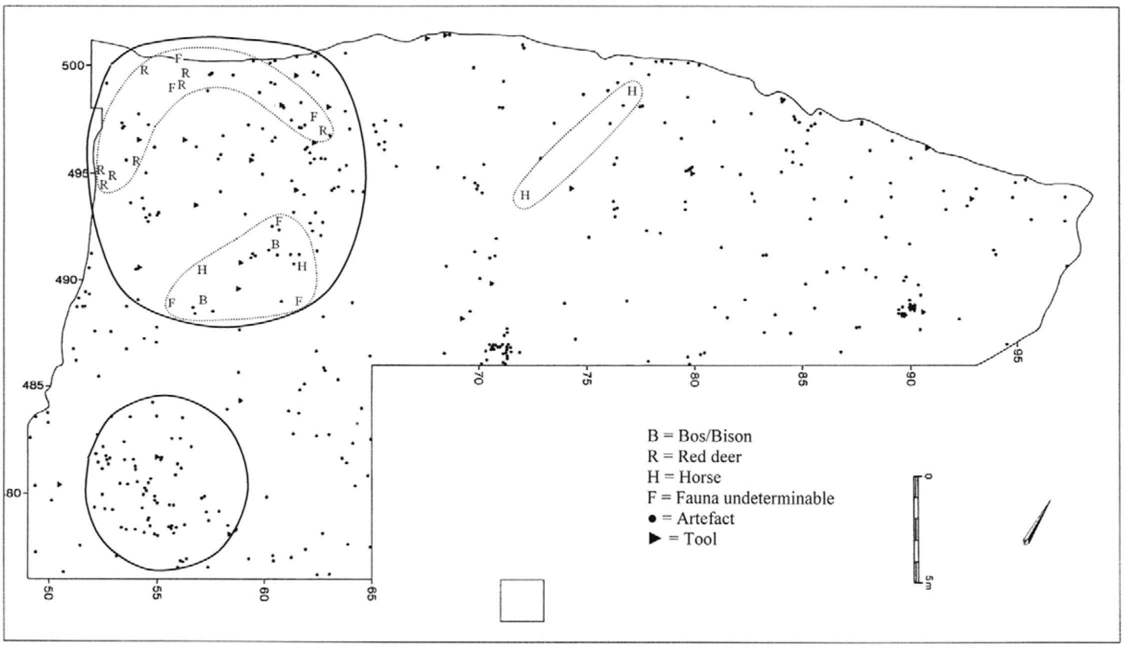

Figure 20. Artefacts and mammal remains at Maastricht-Belvédère Site N, with artefact distribution according to Roebroeks et al. *(1992). The solid lines indicate the zones with the greatest density of artefacts and tools, the dotted lines the zones with the greatest density of fauna. Figure by the author.*

Compared with the HD sites of the lower horizon (HD-I), that of the upper horizon (HD-II) contains artefacts with considerably more numerous natural fissures, the Levallois flaking technology is absent, and is characterised by a lower facettage index (= Index of Faceting: related to blanks with faceted butts) and higher massivity index (= (thickness x 100)/length). If we plot the relationship between these two latter, technology-related parameters and the percentage of natural fissures in the flint (figure 21), it can be clearly seen that the flint in the upper level (the younger of the two occupied horizons) is of significantly poorer quality than that in the lower level (the older of the two). De Loecker assumes that the flint in the upper horizon was obtained from sediments of the river Maas, which he situates in fairly close proximity to the excavated sites (De Loecker, 2006: 182). For the upper level this may be correct. As argued previously, however, at the time of occupation evidenced in the lower level the Maas was in fact further away and the archaeological sites concerned were within the catchment area of the Jeker, then flowing further to the north than it does today. The flint used here was of considerably better quality and may have been sourced in the Jeker basin or possibly even further afield. This has also been shown to be the case at the low-density sites (both in LD-I and LD-II), where the raw materials selected for transport to the site are clearly of superior quality (De Loecker, 2006: 262).

Group	Site	Natural fissures [%]	Levallois technology	Index facettage IF ≥ 30 mm [%]	Massivity index [-]
HD-II	A	31.3	-	12.6	20.6
HD-II	F	42.0	-	12.8	23.5
HD-II	H	38.9	-	20.0	23.4
HD-II	K	25.9	-	18.1	24.9
HD-I	C	2.7	+	50.4	17.3
HD-I	M	3.4	+	44.7	17.6
LD-I	G	22.7	-	22.7	18.7
LD-II	N	5.7	+	27.3	18.1
LD-II	K (tools)	14.7	+	18.5	19.5

Table 8. Raw material quality of flint artefacts at Maastricht-Belvédère, Unit IV. Data based on De Loecker (2006). Note: '+' = present, '-' = not present.

I would therefore suggest that De Loecker's conclusion should be modified to read: […] there are reasons to assume that significant changes in raw material availability (amongst others distance to the flint sources, flint quality, etc.) had taken place during the relatively long period of assemblage formation. Table 9, finally, summarises the main characteristics of the best-studied archaeological sites in Maastricht-Belvédère Unit IV.

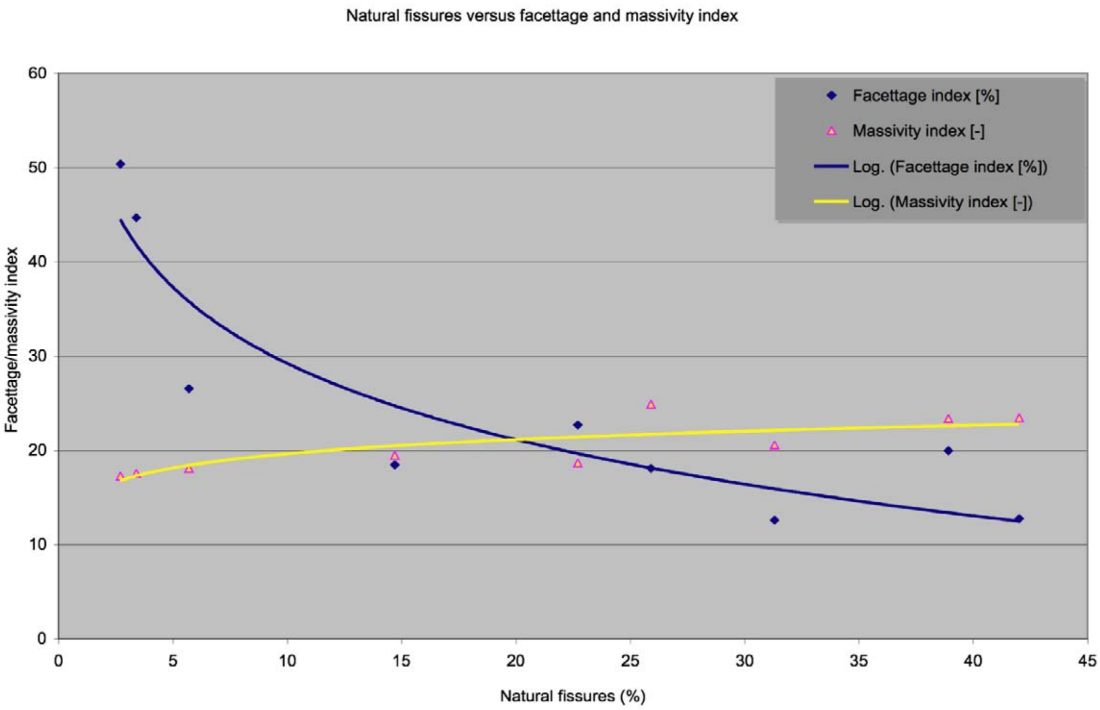

Figure 21. Natural fissures versus facettage index and massivity index from artefacts of Site K. Figure by the author.

Site	Unit IV level	Topography	Area dug	Artefact density		Debitage	Cores		Modified artifacts		Burned artifacts		Macro fauna
			m^2	(n/m^2)		n	n	%	n	%	n	%	
K	II	High	370	High	29.5	9964	91	0.8	137	1.3	617	5.7	-
F	II	High	42	High	28.0	1147	2	0.2	8	0.7	15	1.3	-
C	I	High	264	High	11.6	2896	4	0.1	23	0.7	132	4.3	+
A	II	High	5	High	16.0	74	1	1.3	2	2.5	1	1.3	-
H	II	High	54	High	5.0	259	0	0	10	3.7	1	0.4	-
G	I	Low	50	Low	1.5	67	0	0	8	10.7	0	0	+
N	II	Low	765	Low	0.6	420	1	0.2	26	5.8	1	0.2	+

Table 9. Characteristics of the principal high- and low-density sites of Maastricht-Belvédère Unit IV. Site H is a peripheral zone of a high-density site. Only part of Site A has been studied. Based on De Loecker (2006). Note: '+' = present, '-' = not present.

<u>7. The archaeological significance of traces of fire</u>

7.1. Traces of fire

During the 25 years of prospecting the various quarries in the present catchment area of the Hezerwater brook, besides lithics and bones, traces of fire were also always explicitly sought. During the excavations at the nearby Maastricht-Belvédère quarry in the 1980s, there had been three notable fire-related finds: burnt flints at Site G, several dense concentrations of charcoal fragments up to one cm large together with burnt artefacts at Site C (Roebroeks, 1988) and numerous burnt artefacts at Sites F and K (De Loecker, 1992; Stapert, 2007), all probably associated with human use of fire. The evidence as such was inconclusive, though, and the jury was still out on the issue.

The Kesselt-Op de Schans quarry is the latest quarry in this area to yield traces of fire. Here, on 5 June 2006, in an interglacial soil complex, the author discovered a soil horizon containing numerous charcoal fragments along with a concentration of flint artefacts. The soil is an estimated 300,000 years old (www.archeogeolab.nl).

In this horizon, moreover, a great many charcoal fragments were found in a wider area round the archaeological sites, extending several hectares, along with other evidence of fire. How these traces are to be interpreted is as yet unclear. Wildfire is one possibility. Alternatively, they may (partly) reflect the use of fire at human camp sites, from which the fire was then dispersed across a larger area, away from the sites themselves, whether intentionally or otherwise, as wildfire.

7.2. Natural fires

From various locations in the gravel of the oldest Pleistocene sediments in the Maastricht-Belvédère quarry, pieces of charcoal measuring several centimetres were recovered. In a several decimetres thick clay lens in the middle of the Maas gravel bed (De Warrimont, 2002b), the impressions of leaves and molluscs were found along with numerous charcoal fragments up to one cm in size (figure 22). This clay had been deposited in a wet environment that yielded no evidence of human activity. The charcoal will have been carried into the river valley from the surrounding landscape by wind and rain, eventually to be deposited in the riverbed. The most plausible explanation in this case is that the charcoal derives from a naturally occurring fire.

At the 'Nelissen' quarry at Kesselt, traces of fire as well as charcoal fragments (figure 23) were found in the middle of the Rocourt soil complex (dating from the last interglacial *s.l.*). In addition, several traces of fire in the form of charcoal and red-burnt loam were found in an older interglacial soil (the 'Hees' soil) at two different sites in the quarry, which in both cases appear to derive from the remains of burnt out roots of trees (Gullentops & Meijs, 2002). This is a phenomenon familiar from natural forest fires. There was no evidence for the fire being of anthropogenic origin.

Figure 22. A 30 cm thick layer of clay with charcoal particles from the Maas river terrace gravel in the Maastricht-Belvédère quarry. Photograph by the author.

In the fourth case there are strong indications as to the likely cause of the fire. In the Veldwezelt-Hezerwater quarry numerous charcoal fragments up to several centimetres in size have been found at various places at the top of a dark brown humic steppe soil (OHZB; Early Glacial) that overlies the Rocourt soil complex. In the same horizon from which the charcoal was recovered, Meijs (2002: 119) identified the 'Rocourt tephra', an enstatite-containing tephra deposit originating from volcanoes in the Eifel region. It seems likely that the two phenomena are related, with a volcanic eruption in the Eifel probably setting off the steppe fire from which the charcoal derives.

In the Hezerwater quarry, what is presumed to be a hearth was found in the Allerød soil (figure 12). It is a horizontal, lenticular (lens-shaped) concentration of charcoal at least five cm thick and about one m in diameter (figure 13). It was uncovered by a mechanical digger during excavation of the brickyard loam by employees of Vandersanden-Steenfabrieken, the firm exploiting the quarry. Despite an intensive search, no artefacts were found in this layer. From Upper Palaeolithic studies elsewhere in northwest Europe we know that by this late stage of the Weichselian human occupation of this region was once more possible. The nature of this lenticular body of charcoal and the absence of charcoal elsewhere in this horizon seem to point to this being a hearth once used by our human ancestors. Other finds that might support such a conclusion are lacking, however.

Also noteworthy are several other reports of metres-wide charcoal concentrations clearly visible in the Middle Weichselian loess (OIS 3) passed on by operators of the mechanical diggers. These phenomena could not be investigated, though, as they were destroyed by ongoing quarrying operations before further study was feasible.

Figure 23. A large trace of a natural fire from the Rocourt soil complex in the Kesselt-Nelissen quarry. Photograph by the author.

7.3. Fire as an artefact

One find about which no further conclusions can be drawn is a single, isolated burnt artefact recovered from a tundra soil (MLB: Bringmans *et al*., 1999/2000) at the south end of the Veldwezelt-Hezerwater quarry. In the homogeneous loess of this soil there were no other artefacts or stones that could provide any real clues as to the nature of the find. It is the youngest soil in this quarry to yield a primary context find from the Middle Palaeolithic (OIS 3).

In the interglacial VBLB soil, the most recent of the three luvisols that make up the Rocourt soil complex in the Veldwezelt-Hezerwater quarry, two concentrations of flint flakes were found which refitting showed to be related (Bringmans *et al*., 1999/2000). On a southeast facing slope in the valley of the Hezerwater brook was a site where flint knapping had evidently taken place, while higher up the valley side was an activity zone that yielded a number of stone tools. Only a few of these flint artefacts were burnt. Scattered among the artefacts - with the greatest density in the activity zone - charcoal fragments were recovered, some of them up to several centimetres in size.

A similar situation was encountered at Kesselt-Op de Schans. In this quarry, a concentration of flint artefacts in a layer corresponding stratigraphically with the VBLB horizon in the Veldwezelt-Hezerwater quarry was found in 2001. Most of the artefacts recovered during a rescue excavation of this site were found in a large concentration over an area of about seven m^2 that also contained charcoal fragments up to two cm in diameter. Most of the artefacts could later be refitted into two sequences. Apart from the association with the flint concentrations cited here, no other charcoal was found in the archaeological horizon at either site.

It seems likely that the charcoal derives from hearth-related human activity. Under the influence of weather (prior to covering of the site) and as a result of bioturbation and other post-sedimentary processes, the contents of the hearth or hearths have been scattered, making it impossible to locate their exact original location. In this case, though, the correlation of the charcoal with the archaeological finds is such that here the fire may be assumed to have been of anthropogenic origin.

An example from the Veldwezelt-Hezerwater quarry in which hearths have been better preserved is Site VLB, in a humic soil dated to the late Saalian. This is an interstadial soil with an estimated age of 135,000 years, formed during a warmer climatic phase that preceded the Eemian Interglacial (Bringmans *et al*., 1999/2000). At two locations, one in the south and one in the north, on either side of a 20-m-wide side-valley of the Hezerwater brook (a spring-fed 'amphitheatre'), dense (south-west) to very dense (north) concentrations of charcoal were recovered, along with several burnt flint artefacts and burnt pieces of gravel. In the northern concentration grey ash was also found, and in the south-west a concentration red-burnt loam. No burnt bones were found. The charcoal concentrations were lenticular in profile and about one m in diameter. Some of the charcoal fragments recovered were more than five cm long. The maximum thickness of the central part of the hearths richest in charcoal was over five cm. The size of the hearth and the density of charcoal in the northern concentration was similar to the hearth from the Allerød soil, shown in figure 13. This hearth was dug out in its entirety and taken to Brussels (KBIN) for anthracological study/analysis. The southwestern hearth was more diffuse, with charcoal fragments and lumps of red-burnt loam intermingled in a matrix of grey humic loam.

In the southeast of the site was a third, rather less dense concentration of charcoal, which was associated with two bowl-shaped depressions in the ground about 50 cm in diameter and over ten cm deep. The loam in these depressions, which also contained scatters of charcoal, was lighter in colour than the surrounding humic loam. There is no obvious explanation for this phenomenon. If it were a hearth, one would expect there to be more charcoal. Adjacent to one of these depressions a linear, horizontal concentration of charcoal was found, interpreted as being the remains of a burnt length of wood.

In each of the two southern charcoal concentrations, a 10 to 15 cm deep ground disturbance was discovered slanting into the ground at an angle (figures 24 & 25). These two diagonal traces stood out against the surrounding humic sediment by their lighter colour (diameter about 12 cm) and by the traces of burnt charcoal they contained along their entire length. It is very rare indeed to encounter this kind of phenomenon in a Middle Palaeolithic site. These features are interpreted as being the remains of burnt stakes that once stood in the ground here.

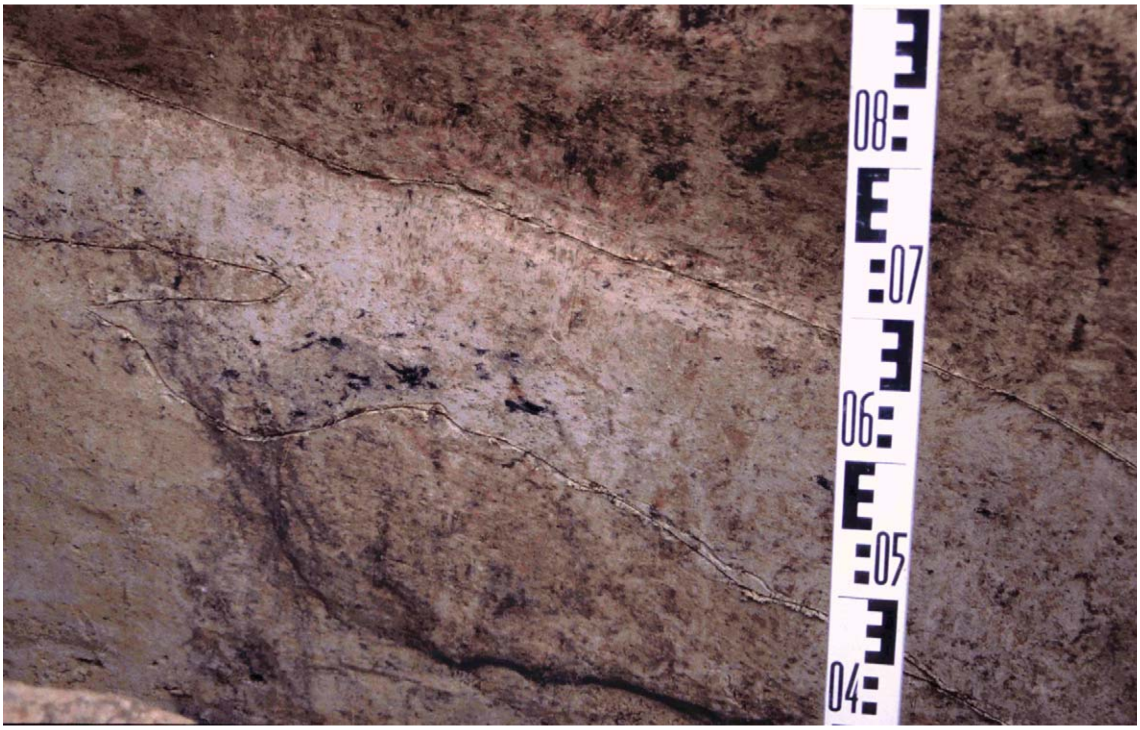

Figure 24. A slanting stake-hole with traces of charcoal from the east-facing wall passing through the south-west charcoal concentration at Site VLB in the Veldwezelt-Hezerwater quarry. Photograph by the author.

In addition, charcoal particles were found scattered across the entire excavation surface of this site. This points to the existence of hearths that were later disturbed by wind and weather, in whole or in part, with the charcoal being deposited elsewhere across the layer in question as thin, horizontal, sometimes linear traces.

Most of the flint artefacts, from which a number of excellent refit sequences could be derived, were found in the vicinity of the three charcoal concentrations, in one case only several decimetres away. Even so, only very few of the artefacts found were burnt.

Rapid sedimentation subsequent to human presence has led to the charcoal in these three concentrations being preserved largely in primary context. This said, though, the remains have undergone a degree of disturbance at a later date through bioturbation, a well-known phenomenon encountered throughout the quarry in layers where interglacial or interstadial soils have formed. Here such disturbance was only limited, however, as evidenced for example by two clusters of flint splinters (chips) near the southern charcoal concentrations and the small areas from which several flint concentrations with numerous refits were recovered. The bulk of the approximately 40 refits from the south-western concentration came from an area measuring only 0.15 m^2 situated immediately next to the hearth (figure 26).

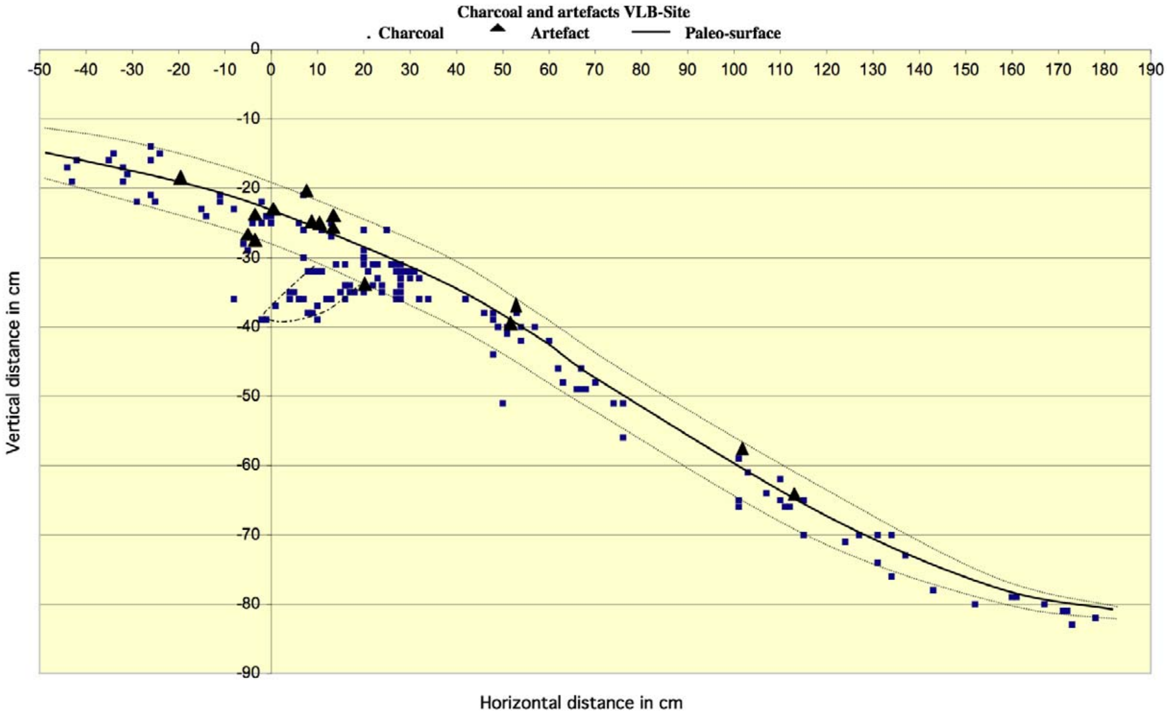

Figure 25. Finds from a seven cm wide cross-section through the stake-hole at the south-west charcoal concentration, showing charcoal and artefacts (mainly flint chips). Figure by the author.

Figure 26. A series of refitted flint artefacts from Site VLB in the Veldwezelt-Hezerwater quarry, recovered from near the south-west charcoal concentration. Photograph by the author.

The campfires uncovered at this Middle Palaeolithic site are similar to those found in the Upper Palaeolithic site at Krems/Hundssteig in Austria (Einwögerer, 2002): simple lenticular hearths 0.5-1 m in diameter around which the majority of the artefacts from these sites were recovered.

Damblon (KBIN Brussel, 1998) has examined the charcoal finds from the Veldwezelt-Hezerwater quarry and identified two species of wood: pine (*Pinus sylvestris*) at Site VLB and in the OHZB horizon and birch (*Betula sp*.) at Site VBLB (Bringmans *et al*., 1999/2000).

7.4. Conclusions

In the Pleistocene sediments of the study area, macroscopic traces of natural fires are only rarely encountered. In twenty-five years of intensive prospecting in the four quarries reviewed, such traces have been found just four times in interglacial or interstadial soils (table 10). The fifth example, still under study in 2007, in the complex find horizon of primary context Site 2 at the Kesselt-Op de Schans quarry, is not recorded in this table. This is exclusive of finds associated with erosional processes recovered from secondary deposits; cases in point include scattered finds in river gravels and in erosion gullies and the tertiary rolled pebbles (known locally as 'Maas eggs') with potlids or a conspicuous, red-burnt colour recovered from pleistocene loam and displaced tertiary deposits. All the archaeological sites - over 16 in all - found in a primary context derive from these interglacial or interstadial soils and a relatively high proportion of them (~ 45%) yielded clear signs of fire. This does not include the three sites from which only a single burnt artefact was recovered (Maastricht-Belvédère Sites A, H and N), which would push this percentage even higher.

Oxygen Isotope Stage	Soil//Site	Quarry	Natural fire remains	Human-induced fire remains	Indefinite
OIS 2	Allerød soil	Veldwezelt-Hezerwater			charcoal
OIS 3	MLB	Veldwezelt-Hezerwater			burnt artefact
OIS 5/4	OHZB	Veldwezelt-Hezerwater	charcoal		
OIS 5a	VBLB	Veldwezelt-Hezerwater		charcoal burnt artefacts	
OIS 5a	VBLB	Kesselt-Op de Schans		charcoal	
OIS 5	Rocourt soil complex	Kesselt-Nelissen	charcoal		
OIS 6.01	VLB	Veldwezelt-Hezerwater		charcoal, ash, burnt loam burnt artefacts	
OIS 7c	F	Maastricht-Belvédère		charcoal burnt artefacts	
OIS 7c	K	Maastricht-Belvédère		burnt artefacts burnt stones	
OIS 7e	C	Maastricht-Belvédère		charcoal burnt artefacts burnt stones	
OIS 7e	G	Maastricht-Belvédère		burnt stones	
OIS 7	Hees soil	Kesselt-Nelissen	charcoal burnt loam		
OIS 8	Gravel & clay layer in gravel	Maastricht-Belvédère	charcoal		

Table 10. Remains of natural and human-induced fires from the quarries near Maastricht. This does not include archaeological sites from which only a single burnt artefact was recovered.

The fact that macroscopic traces of natural fires are rare in Pleistocene soils means the likelihood of these just happening to coincide with sparse Palaeolithic sites is minimal. With respect to the study area, then, this means we have convincing traces of human use of fire dating back to at least about 250,000 years ago. Even though the only traces of fire encountered in an archaeological context are in the form of burnt stones or burnt flint artefacts or scattered fragments of charcoal, it is extremely likely - certainly in this loess region - that they derive from (early) human use of fire.

In archaeological publications insufficient consideration is often given to interpreting any traces of fire found. As illustrated here, though, while such traces may be restricted to burnt artefacts or charcoal scatters, they may still yield convincing evidence of human use of fire.

At the Middle Weichselian sites WFL and TL in the Veldwezelt-Hezerwater quarry (Bringmans *et al.*, 1999/2000) no traces of fire were found. These sites can be compared with the low-density Site N in the Maastricht-Belvédère quarry (Roebroeks *et al.*, 1992). It would appear that the recurrent human visits here were only brief. These sites are located in the lower-lying, wetter parts of the landscape (Vandenberghe, 1995), along the Hezerwater brook, while fire-making was an activity carried out higher up the valley sides.

At the sites with unmistakable traces of fire, which appear to be evidence of hearths, flint-knapping products were also found, a significant proportion of which could be refitted. This points to human occupation over a somewhat longer period, more specifically at Sites VBLB and VLB in the Veldwezelt-Hezerwater quarry, Site VBLB in the Kesselt-Op de Schans quarry and Sites C and K at Maastricht-Belvédère.

The two presumed stake-holes were discovered more or less by chance. One of these disturbances in the ground was discovered during the scraping-back of a profile prepared for a geostratigraphic survey, while the other was found in the vertical side-wall of an excavation pit. The excavation method employed, with its 2 x 2 m horizontal checkerboard grid, is not well-suited to finding these kinds of traces. For practical reasons, moreover, charcoal fragments were not always point-plotted, leading to distortion of the charcoal distribution pattern. When charcoal fragments were scarce, a relatively high proportion was point-plotted; when they were frequent, a relatively low proportion. As a result, these residues were difficult to trace during the excavations and hard to reconstruct from later drawings.

8. The archaeological significance of the macrofaunal remains

In Pleistocene soils, well-preserved remains of mammal faunas are found only in deposits that have not been too severely weathered (*e.g.* Maastricht-Belvédère Site N) and where the calcium component of the soil has not yet been entirely lost, as in the interstadial soils formed in calcareous loess (*e.g.* Veldwezelt-Hezerwater Sites TL and WFL) or locations where finds have been preserved in and below calcareous tufa (Maastricht-Belvédère, Unit IV - lower sites). The outer surface of the bones recovered from these soils has been eroded to such an extent that any cut-marks that might have remained after butchering activities by early humans are no longer visible. These bones can still be identified to species level, however (Van Kolfschoten, 1988; Bringmans, 2006: 281-287).

In the soils of these quarries it is only rarely that a rich macrofaunal assemblage is found, here taken to mean concentrations of bones of large mammals, comprising multiple species and/or individuals. To date, seven such assemblages have been discovered, six of which were associated with larger numbers of human artefacts: Sites B, C, G and N in the Maastricht-Belvédère quarry and Sites WFL and TL in the Veldwezelt-Hezerwater quarry (table 11). The seventh assemblage may reflect a natural background fauna. In this case the remains were recovered from the MLMB soil (Bringmans *et al.*, 1999/2000) in the Veldwezelt-Hezerwater quarry, which overlies Site WFL. This background assemblage consists of the bones of animals that have died a natural death or succumbed to predators.

Primary context site	Archaeology	Macrofauna concentration
Maastricht-Belvédère Site B	+	+
Maastricht-Belvédère Site C	+	+
Maastricht-Belvédère Site G	+	+
Maastricht-Belvédère Site N	+	+
Veldwezelt-Hezerwater Site WFL	+	+
Veldwezelt-Hezerwater TL sites	+	+
Veldwezelt-Hezerwater MLMB	-	+

Table 11. Primary context sites with remains of multiple mammals and/or mammal species. Note: '+' = artefacts or macrofauna present, '-' = no artefacts or macrofauna present.

Few bones have been found in interglacial and interstadial soils containing no artefacts and where they can generally be traced to a single animal. In addition to the aforementioned primary context sites there are also several secondary context assemblages, that is, assemblages yielding bones from several large mammals intermingled with artefacts in what is clearly a disturbed context (table 12). These are usually encountered in the bottom sediment of erosion gully infill or in deflation horizons, where highly fragmented remains (bones and teeth) of larger mammals are sometimes found together with worked flint in a matrix of coarser erosional debris (sand, gravel, soil concretions). As yet, only one such concentration of bones has been found unaccompanied by artefacts: in a Weichselian erosion gully at the Kesselt-Nelissen pit (personal communication Meijs).

The reworked artefacts recovered from this kind of context are generally heavily weathered, with worn edges and ridges, and frequently have a 'gloss' and colour patina. These phenomena are most pronounced in deflation horizons, where high-gloss artefacts are often to be found. Artefacts in deposits that have been subject to periglacial processes (the action of frost, as with cryoturbation under periglacial conditions) often have a whitish patina and gloss and are typically characterised by frost cracks, frost fissures and forms of 'cryoretouche'.

Secondary context site	Archaeology	Macrofauna concentration
Maastricht-Belvédère Site E	+	+
Maastricht-Belvédère Site M	+	+
Veldwezelt-Hezerwater ML 1995	+	+
Veldwezelt-Hezerwater ML 1996	+	+
Kesselt-Nelissen quarry 2002	+	+
Kesselt-Nelissen quarry 2004	+	+
Kesselt-Nelissen Weichselian gully	-	+
Kesselt-Op de Schans quarry 2004/2005	+	+
Kesselt Albert Canal 1983	+	+

Table 12. Secondary context sites with bones of large mammals. Note: '+' = artefacts or macrofauna present; '-' = no artefacts or macrofauna present.

The fact that rich background faunal assemblages are rare in Pleistocene soils means there is little likelihood of these just happening to coincide with Palaeolithic sites. In over 85% of the faunal assemblages investigated flint artefacts were found. The conclusion must surely be that the faunas encountered at these archaeological sites are the remains of animals hunted by early humans, despite the lack of any direct evidence in the form of cut-marked bones. An additional indication is provided by the fact that at Maastricht-Belvédère Sites C and G, where microwear studies have been carried out to identify wear marks on flint artefacts, traces have been found that point to butchering activities (Van Gijn, 1988). The faunas from the archaeological sites are thus not to be seen as natural background assemblages, but are of key archaeological significance.

9. Overall conclusions

As a result of the collaboration between archaeologists and geologists based in the region and reseachers from the universities of Leiden and Leuven, over twenty-five Middle Palaeolithic archaeological sites have been investigated between 1981 and 2007. In these efforts they were supported by numerous volunteers from the wider region around Maastricht and by students and specialists from universities and institutes in several countries. By means of extensive geostratigraphic studies of the exposed loess deposits and a variety of physical dating methods, it has been possible to elaborate a reliable chronological framework for the occupation of Maastricht's peripheral zone by Pleistocene humans. According to present understanding, Middle Palaeolithic occupation took place during several interglacials and interstadials between 300,000 and 50,000 years ago.

This has been a case of multidisciplinary and international collaboration that has proved highly fruitful, in which volunteers, regional scientists and professional researchers from institutes have all made important contributions and whereby a substantial body of knowledge has been built up on the Pleistocene occupation of this corner of Flanders and The Netherlands. Thanks to the numerous excavations undertaken here, a convincing argument can be made that the macroscopic traces of fire and macrofaunal remains recovered from the various archaeological sites are not natural phenomena but artefacts, *i.e.* traces of intervention by early humans.

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