Magnetists and thus should make use of those techniques. Although the field of Environmental Magnetism has continued its rapid development, archaeological applications over the past decade have tended to focus on field applications of susceptibility. There is thus much potential for expanded use of the entire range of magnetic techniques to answer questions relating to past climates, dating, formation, and postdepositional processes central to understanding the relationship of humans to their environment.

Cross-References

► Anthropogenic Environments, Archaeology of
► Anthropogenic Sediments and Soils: Geoarchaeology
► Geoarchaeology
► Landscape Archaeology
► Prospection Methods in Archaeology

References

Banerjee, S.K. 1981. Experimental methods of rock magnetism and paelomagnetism. *Advances in Geophysics* 23: 25-99.

Bazylinski, D.A. & B.M. Moskowitz. 1997. Microbial biomineralization of magnetic iron minerals: microbiology, magnetism and environmental significance. *Reviews in Mineralogy and Geochemistry* 35: 181-223.

Clark, A.J. 1996. *Seeing beneath the soil: prospecting methods in archaeology*. London: B.T. Batsford.

Dalan, R.A. 2006. Magnetic susceptibility, in J. Johnson (ed.) *Remote sensing in archaeology: an explicitly North American perspective*: 161-203. Tuscaloosa: The University of Alabama Press.

- 2008. A review of the role of magnetic susceptibility in archaeogeophysical studies in the United States: recent developments and prospects. *Archaeological Prospection* 15: 1-31.

Dalan, R.A. & S.K. Banerjee. 1998. Solving archaeological problems using techniques of soil magnetism. *Geoarchaeology* 13: 3-36.

Dearing, J.A., B.A. Maher & F. Oldfield. 1985. Geomorphological linkages between soils and sediments: the role of magnetic measurements, in K.S. Richards, R.R. Arnett & S. Ellis (ed.) *Geomorphology and soils*: 245-266. London: Allen and Unwin.

Dearing, J.A., R.I. Morton, T.W. Price & I.D.L. Foster. 1986. Tracing movements of topsoil by magnetic measurements: two case studies. *Physics of the Earth and Planetary Interiors* 42: 93-104.

Evans, M. & F. Heller. 2003. *Environmental magnetism: principles and applications of environmagnetics*. New York: Academic Press.

Hunt, C.P., B.M. Moskowitz & S.K. Banerjee. 1995. Magnetic properties of rocks and minerals, in T.J. Ahrens (ed.) *Rock physics and phase relations: a handbook of physical constants* (AGU Reference Shelf 3)*:* 189-204. Washington (DC): American Geophysical Union.

Maher, B.A. 1986. Characterisation of soils by mineral magnetic measurements. *Physics of the Earth and Planetary Interiors* 42: 76-92.

Mullins, C.E. 1974. The magnetic properties of the soil and their application to archaeological prospecting. *Archaeo-Physika* 5: 143-347.

- 1977. Magnetic susceptibility of the soil and its significance in soil science – a review. *Journal of Soil Science* 28: 233-46.

Thompson, R. & F. Oldfield. 1986. *Environmental magnetism*. London: Allen and Unwin.

Verosub, K.L. & A.P. Roberts. 1995. Environmental magnetism: past, present and future. *Journal of Geophysical Research* 100: 2175-92.

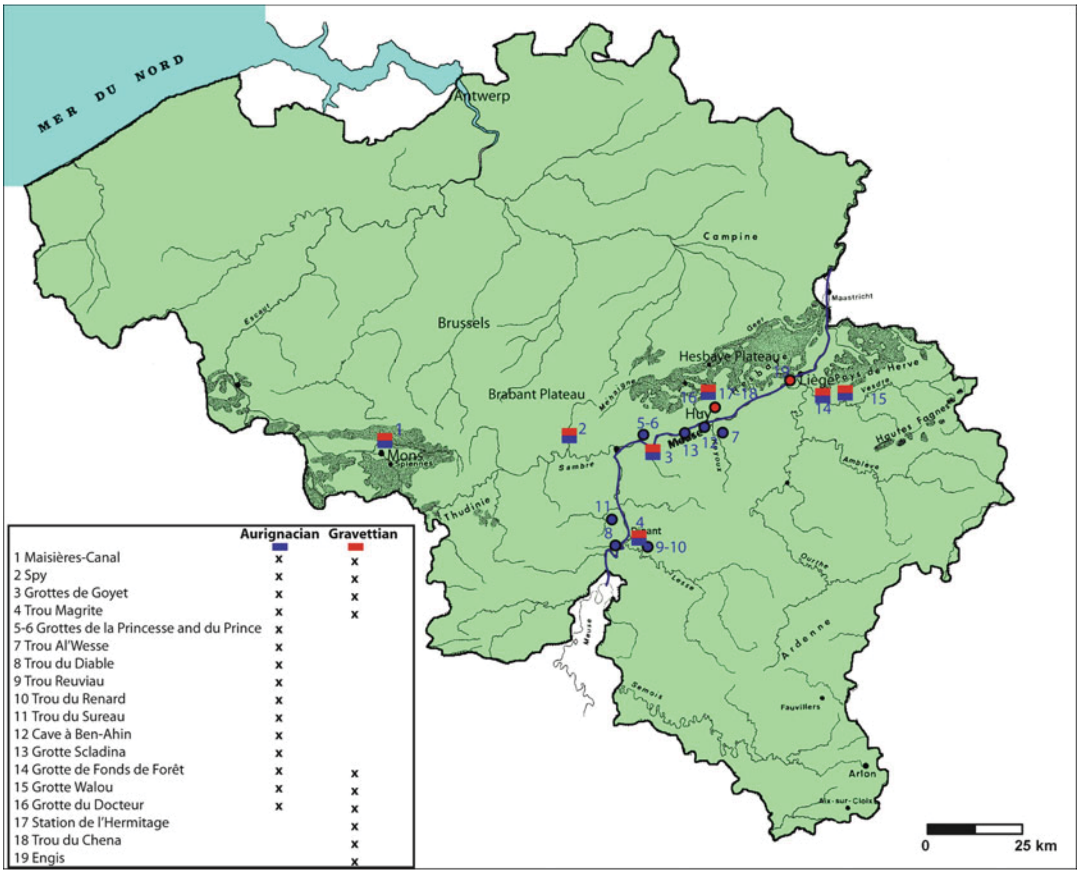
Maisières-Canal: An Open-Air Aurignacian Workshop

Rebecca Miller
Service of Prehistory, University of Liège, Liège, Belgium

State of Knowledge and Current Debates

Introduction

The Early Upper Paleolithic in Belgium is known primarily from cave sites located in the Meuse Basin, rarely from open-air sites. Until the discovery of the Aurignacian workshop at Maisières-Canal, Aurignacian occupations were known only in caves (Fig. 1), apart from isolated surface finds near Braine-le-Comte (Fourny & van Assche 1992). The situation is similar for the Gravettian, with the addition of two in situ open-air sites (Fig. 1). Most Belgian Paleolithic sites were first excavated in the nineteenth century, and thus lack precise stratigraphic and chronological data, not to mention limitations



Maisières-Canal: An Open-Air Aurignacian Workshop, Fig. 1 Map showing the principal Aurignacian and Gravettian sites in Belgium

in the lithic and faunal assemblages due to excavation bias.

In the last 25 years, excavations have been undertaken both in new caves (Grotte Walou: Dewez 2008; Pirson et al. 2011; Grotte Scladina: Otte 1992; Otte et al. 1998) and in those previously excavated (Trou Magrite: Otte & Straus 1995; Grottes de Goyet: Toussaint et al. 1999; Grotte du Docteur: Miller et al. 1998; Otte & Miller 2000). Such research yielded new data for the Paleolithic, including Aurignacian and Gravettian occupations, making it possible to establish a regional chronostratigraphic sequence, reconstruct Pleistocene palaeoenvironments, and to address different aspects of prehistoric hominid behavior.

However, such cave sites represent only a part of the range of human activities that took place across the landscape, being occupations of variable duration in the region of Middle Belgium that provided primary access to shelter, water, and fuel, as well as subsistence resources. Open-air sites, which could include short-term camps, hunting stands, kill or butchery sites, and lithic workshops, among others, complement cave sites and represent a broader range of activities. These are rare in Belgium and their discovery has been dependent on public works: Maisières-Canal was discovered in the 1960s as a result of the modernization of the Canal du Centre, the Station de l'Hermitage at Huccorgne in the late nineteenth century when a railroad was cut through the deposits. Huccorgne was also more recently excavated in the 1970s by Destexhe and Haesaerts, and then in the early 1990s by Straus, Otte, and Haesaerts

(Straus et al. 2000). Both sites are Gravettian; the only open-air Aurignacian site, the subject of this entry, was discovered by chance during re-excavation at Maisières-Canal.

Given the rarity of open-air sites in Belgium, new excavations were undertaken at Maisières-Canal in 2000–2002, with the initial aim of expanding the excavation in the "Atelier de Taille de la Berge Nord-Est" zone, which contained a small Gravettian assemblage. While little additional Gravettian material was found, the limits of the occupation were defined and the discovery of an intact Aurignacian level in one of the test trenches reoriented the aims of the project. These focused on the establishment of the chronostratigraphic context, clarification of the technological activities at an Aurignacian flint workshop, its role within the regional lithic economy, and the relationship between open-air and cave sites.

This entry presents a summary of the results obtained through geological and technological analyses, published in greater detail in the recent monograph (Miller et al. 2004).

Location and Description of the Site

The site of Maisières-Canal is located next to the Canal du Centre, near the limits between the villages of Maisières and Obourg in western Belgium (50° 28'55" N, 3° 58'37" E). It includes two zones (Fig. 2a): the *Champ de Fouilles*, covering an area of 95 m^2, excavated in 1966–67 by J. de Heinzelin and P. Haesaerts for the Royal Belgian Institute of Natural Sciences (de Heinzelin 1971, 1973; Haesaerts 1973; Haesaerts & de Heinzelin 1979) and now beneath the canal, and the *Atelier de Taille de la Berge Nord-Est*, a small zone at the time covering 3 m^2 on the Northeast Bank of the canal, around 100 m from the Champ de Fouilles and excavated by P. Haesaerts. Both zones contained Gravettian occupations, the principal occupation in the Champ de Fouilles zone with a rich lithic and faunal assemblage, and a small workshop site in the Atelier de Taille zone. Recent fieldwork yielded the new Aurignacian workshop in the latter zone (Fig. 2b).

Research at Maisières-Canal by the Royal Belgian Institute of Natural Sciences for the first time provided comprehensive information concerning an Upper Paleolithic open-air site in Belgium, integrating data from the archaeology, stratigraphy, vertebrate paleontology, malacology, palynology, and radiometric dates. The Atelier de Taille was considerably altered by modernization of the existing canal. Landscaping on the Northeast Bank truncated the upper part of the Gravettian layer. A 4-m-wide drainage ditch cuts directly through the deposits. Archaeological material was found on both sides; part of the site was thus clearly lost.

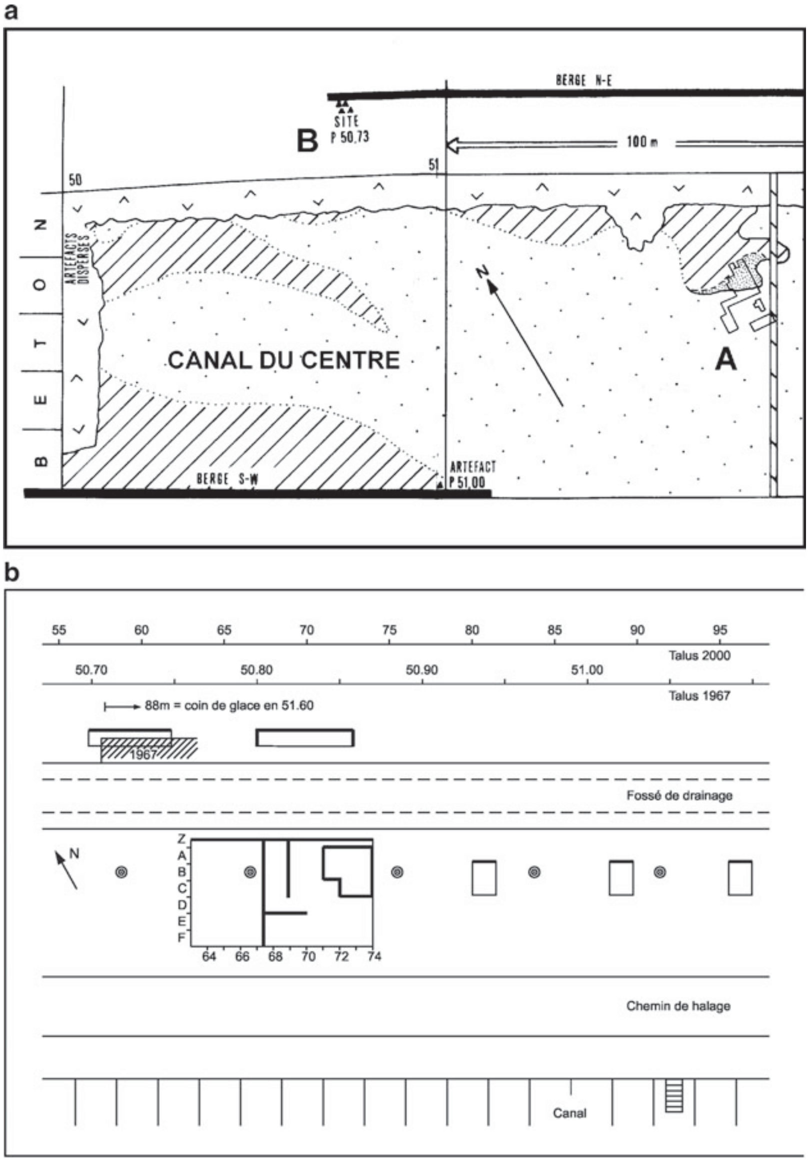
Core sampling and test pits around the excavated zone indicate that the deposits are coherent with the stratigraphy of the site. However, the Gravettian occupation is restricted by chalk flow and the geological layer containing the Aurignacian occupation plunges abruptly to the southeast to a depth of 4 m below the surface and is sterile in three test pits.

Both occupations were situated at the top of a small hill overlooking the ancient Haine River. The Haine followed a wide synclinal depression oriented east–west. To the north, the depression is delimited by Cretaceous chalks in contact with the Hainaut Plateau (Haesaerts & de Heinzelin 1979: 9). Obourg flint would have been easily accessible and abundant in the chalks, at a maximum distance of 1 km and likely available in the eroded chalk flows directly at the site. Maisières-Canal was also ideally located for the exploitation of faunal and vegetal resources in the river valley and on the plateau as well as for obtaining good quality flint.

Stratigraphic Context

The 1966–1979 Stratigraphic Sequence

The exceptional character of the sedimentary sequence preserved at Maisières-Canal is linked in large part to the position of the site on the north edge of the alluvial plain of the Haine River, upstream from the Nimy lock and near the mouth of the Wartons stream that drains the northern slope of the valley. In this context, earthworks for the canal enlargement provided access to deposits situated between 36 and 27.50 m ASL over a long distance, on the edge of and below the alluvial plain of the Haine.



Maisières-Canal: An Open-Air Aurignacian Workshop, Fig. 2 (**a**) Maisières-Canal site plan showing the Champ de Fouilles and Atelier de Taille de la Berge Nord-Est (IRSNB excavations), (**b**) site plan for the Atelier de Taille (2000–2002 excavations)

The stratigraphy of the site was established on the basis of three groups of profiles located on the southwest bank between 33 and 27.50 m ASL, the Champ de Fouilles at the bottom of the new canal between 29 and 27.50 m ASL, and on the Northeast Bank between 36 and 33 m ASL. The southwest bank, near the center of the valley, exposed the fluviatile deposits of the Haine. These were also visible at the Champ de Fouilles where they came between a double generation of colluvial deposits at the base of the slope. Each colluvial deposit contained a humus-bearing horizon dated by the Groningen laboratory to 27,965 BP and 30,780 BP on sediment samples (Bastin 1971; Gilot 1971; de Heinzelin 1973). The Champ de Fouilles deposits are laterally attached to the lower part of the sequence on the Northeast Bank, overlain by a complex of loess, silty colluvial, and fluviatile deposits from the Wartons stream preserved over a length of several hundred meters between 35.50 and 32 m ASL, and capped by Lateglacial eolian sands.

The Gravettian Occupation

The Gravettian occupation was largely destroyed by canal earthworks, but remained intact at the Champ de Fouilles between 28.50 and 28 m ASL in the lower third of the second humus-bearing horizon (Unite MH). According to de Heinzelin (1973), the area of occupation likely extended the length of a silty promontory joining the valley floor with the northern slope. This appears to be supported by the discovery of the Gravettian workshop in September 1966, at 34 m ASL on the Northeast Bank. This was dated to around 28,000 uncal BP (Haesaerts & de Heinzelin 1979), recently confirmed by new dating of the Gravettian in the Champ de Fouilles zone (Jacobi et al. 2010).

The Middle Weichselian

The Gravettian occupation was situated near the Haine River, at the beginning of a subarctic climatic episode with grass cover dominated by cyperaceaes. Defined as the "Maisières oscillation," this episode is clearly distinct from the lower humus-bearing layer (Unit MD) dated to 30,780 BP, which is attributed to the Denekamp interstadial known from the Netherlands (Vogel & van der Hammen 1967).

The Maisières oscillation was followed by climatic deterioration evidenced at the Champ de Fouilles by periglacial fluviatile deposits (Units MM and MN) incorporating blocks of the underlying humus-bearing layer displaced under the pressure of ice. The ensemble is covered by a clay flow coming from the slope (Unit MO). This climatic deterioration that ends the Middle Pleniglacial is also demonstrated in the Northeast Bank sequence at the top of the silty layer (Unit NDC) containing the Gravettian workshop, where it is marked by tundra gley (Unite NEA) formed under permafrost, here again followed by a thixotropic clay flow (Unit NEB).

The Upper Pleniglacial

At the Champ de Fouilles and the Southeast Bank, a fluviatile aggradation with a strong silt component was deposited after the clay flows and raised the water level of the Haine above 30 m ASL; it is temporarily interrupted in the lower third by the formation of a thin humus-bearing soil (Unit MPD) attributed to the "Wartons oscillation." On the valley slopes, the beginning of the Upper Pleniglacial is also accompanied by the deposition of loessic silts (Unit NEC), followed by a homogeneous loess (Unit BED1). This is overlain by thick bedded loess (Unit NED2) that covers the slope between 35.50 and 32 m ASL and is linked on the southwest bank with a complex of obliquely stratified sands and silty sands associated with a network of braided channels that block the valley to 31 m ASL. After a brief stabilization marked by a cryoturbated peaty horizon, the fluviatile aggradation is followed in the valley above 32.50 m ASL.

At Maisières-Canal, the alluvial plain of the Haine remained stabilized at around 32.50 m ASL during the second half of the Upper Pleniglacial; several generations of channels were incised to 32 m ASL by the Haine and its affluent, the Wartons stream. On the northeast bank, these channels, blocked with sand and bordered by silty alluvium, migrated laterally and were progressively buried by silty-sand colluvia (Units NF to NK). During this period, the climatic context remained relatively cold and clearly humid with several episodes of cryoturbation and probably a temporary renewal of loess deposits in the upper part of Unit NH. Three minor climatic improvements took place, however, during this period, as indicated in the pollen diagrams by the expansion of pine, alder, and hazelnut (Bastin 1971), in Unit NF and at the base of Unit NG (possibly equivalent to Laugeries), then at the top of Unit NK (possibly equivalent to Lascaux).

The Lateglacial and the Holocene

At the end of the Upper Pleniglacial, probably around 16,000 BP, the water level of the Haine descended below 32 m ASL, immediately prior to a significant cold period indicated by a polygonal network of large ice wedges at the base of a double generation of covering sands (Units NUA to NUE), extending across most of the valley slope. These are separated by broken flints that indicate a deflation surface associated locally to a humus-bearing horizon of "Usselo" type, attributed to the Alleröd. The Maisières-Canal sequence ends with the development of valley peat between 9,000 and 4,700 BP, followed by clayey alluvium deposited after the Neolithic.

The Western Sector of the Northeast Bank (1966–1979)

It was the discovery by J. de Heinzelin in 1966 of the Gravettian workshop on the extension of the promontory connecting the Champ de Fouilles with the Northeast Bank that permitted the link with the loess stratigraphy preserved on the north slope of the valley. The loess was deposited at the top of clay flows mixed with glauconiferous Paleocene sands (Unit NSV). The loess deposits begin with a meter of loessic silt with chalk granules (Unit NBC), overlain by a heterogeneous sandy silt (Unit NCA) incorporating a bioturbated grayish-brown horizon with tiny oxidation stains (Unit NCB) in the upper part. The top is identified by a sine undulating layer of light gray clayey silt. The ensemble was attributed to a hydromorphic soil in relation with the stabilization of the water level of the Haine around 33 m ASL (Haesaerts 1974; Haesaerts & de Heinzelin 1979), during an interstadial episode characterized by a dominance of liguliflorae and a continuous curve for *Betula*, *Alnus*, and *Corylus* in the pollen diagrams.

The units above NCB include two heterogeneous silty-sand deposits (Units NDA and NDC) that evidence a renewal of eolian deposition, largely mixed by runoff, in a cooler and more steppic context marked by an expansion of grasses (Bastin 1971). These deposits are separated by fine lenses of light gray silt (Unit NDB) continuous with the top of NDA; these appear to be the vestiges of a tundra gley formed during a phase of extreme cold, subsequently elongated by solifluction (Haesaerts 1974; Haesaerts & de Heinzelin 1979).

The Gravettian workshop was discovered between squares P50.71 and P50.75 in the lower part of Unit NDC. The lithic artifacts are similar to those found in the Champ de Fouilles occupation and include primarily blades; these are interspersed with bone fragments, many of which are calcined. The area excavated in September 1967 was located at the edge of the workshop; the lithic material was likely displaced by runoff, as indicated by its distribution in elongated lenses following a slight downward slope to the north. The overlying chalk flow (Unit NEB) cuts into the workshop layer west of P50.70 and can be followed to 32 m ASL in P50.60.

Unit NEB extends from a thick deferrified horizon (Unit NEA) that developed at the top of the NDC silts beyond P50.75. This horizon has all the characteristics of a tundra gley with deep ice segregation structures and indicates a period of significant climatic deterioration accompanied by the stabilization of a permafrost landscape (Haesaerts & Van Vliet 1974; Haesaerts & Van Vliet-Lanoë 1981), the NEB chalk flow being likely associated with the phase of permafrost degradation. In the western sector of the Northeast Bank, the loess cover overlying the tundra gley includes three generations of eolian deposits. Sedimentation begins by a loessic silt with chalky granules (Unit NEC) preserved in the lower parts of the landscape, followed by a homogeneous loess (Unit NED1) which goes above 36 m ASL between P50.50 and P50.85, and finally, an obliquely bedded loess of "niveo-eolian" type, deposited on the valley slope after P50.80 where the deposits are cut by the fluviatile channels of Units NF to NK.

The Aurignacian Occupation

The Aurignacian assemblage was found in Unit NBD, which is a homogeneous gray-brown silt 25–30-cm thick, lacking chalk granules, presenting a well-developed porosity, with some small biogalleries. This silt directly underlies the sandy silt of Unit NCA in all three of the trenches excavated. The upper limit of NBD is clear and slightly undulating, while the lower limit is irregular and characterized by a network of small biogalleries penetrating the top of underlying Unit NBC. NBC consists of a loessic silt with chalk granules and overlies the glauconiferous sands of Unit NSV in which the upper part contains a highly bioturbated horizon of browner sand (Unit SVH).

New data obtained for Maisières-Canal confirm the complexity of the Middle Pleniglacial sequence and permit the insertion of an Aurignacian component which, until now, was lacking in the loess record in Middle Belgium. In particular, recently obtained dates (Jacobi et al. 2010) clearly situated the Maisières oscillation at around 28,000 BP and confirm the validity of the 30,780 BP date obtained for the lower humus-bearing soil at the Champ de Fouilles, which would be younger than layer NBD containing the Aurignacian workshop on the Northeast Bank. In comparison with the new climatic and chronological sequence proposed by T. van der Hammen (1995) for the fluviatile deposits of the Middle Pleniglacial in the eastern part of the Netherlands, the humus-bearing soil MD of the Champ de Fouilles and the bioturbated horizon NCB of the Northeast Bank would be correlated with the Denekamp I interstadial dating between 30,000 and 30,500 BP. The Maisières oscillation, slightly more recent than the Denekamp II interstadial, would be situated between 28,500 and 29,000 BP, to which the humus-bearing silt MD and the sandy silts NDA are attributed. According to this schema, the Aurignacian workshop and Unit NBD would be attributed to the Huneborg II interstadial dating between 32,000 and 33,300 BP in the Netherlands sequence.

The stratigraphic data from the Northeast Bank is also of importance to place the Maisières-Canal sequence in the regional context of the Upper Pleistocene in Middle Belgium, using the Cuesta of Harmignes sequence on the southern slope of the Haine basin (Haesaerts 1974; Haesaerts & Van Vliet 1974). Here again, it is the comparable lithostratigraphic and climatic signatures that serve to make correlations between the two systems; these correlations are centered on the tundra gley NEA associated with climatic deterioration following the Gravettian occupation at Maisières-Canal and which constitutes a stratigraphic marker for the limit between the loess silts of the Middle Pleniglacial and the loess cover of the first half of the Upper Pleniglacial. The conjunction of the record at Maisières-Canal and the Cuesta of Harmignies permits the reconstruction of a pedosedimentological and climatic sequence covering the Upper Pleistocene and can be integrated with the stratigraphies at the sites of the Station de l'Hermitage and Remicourt west of Liège (Haesaerts et al. 1999), which serve as reference sequences for the Hesbaye loess.

In conclusion, the coexistence at Maisières-Canal of both Aurignacian and Gravettian workshops within a complex stratigraphic sequence well-situated chronologically constitutes an exceptional reference element for the loess sequence of northwest Europe where Early Upper Paleolithic open-air sites in stratigraphic context are extremely rare. For comparison, the Gravettian occupation of the Station de l'Hermitage at Huccorgne is more recent than that of Maisières, and is associated with the initial loess deposits of the Upper Pleniglacial, probably around 26,000 BP (Haesaerts 2000). The Aurignacian occupation at Maisières is comparable to Lommersum in the Rhine Valley southwest of Cologne (see Hahn 1977; Terberger & Street 2003).

Site Taphonomy

Taphonomic analysis was done to evaluate the integrity of the context of the Aurignacian assemblage. Six different sources of data were exploited: (1) unit slope, (2, 3) artifact orientation and inclination, (4) lithic raw material, (5, 6) vertical distribution of artifacts and spatial distribution of refits. Results complement stratigraphic analysis and demonstrate that the occupation is in situ, with minor displacement due to post-depositional cryoturbation. The slope of Unit NBD was evaluated on the basis of transversal and longitudinal profiles and the position of artifacts in the lower portion of the unit. The unit slopes slightly downward to the NNE and is nearly horizontal NNW-SSE, indicating that slope processes would have had little role in the movement of artifacts. Artifact orientation was used as a proxy indicator of the direction of possible movement of artifacts. Similarly aligned artifacts would indicate a process of systematic displacement of artifacts, for example, along a streambed or slippage down a hill slope. Orientation was recorded for artifacts that were longer than wide ($n = 283$). Artifacts show a small tendency (39 %) to be oriented NNE, along the slope of the unit, suggesting some lateral downhill displacement. Artifact inclination (horizontal, oblique, or vertical) along the longitudinal axis was measured for 871 artifacts. The majority are horizontal are slightly oblique (69 %), but 31 % are oblique or vertical, reflecting some displacement due to cryoturbation. Diversity and variability in lithic raw materials in an assemblage can serve as an indicator of possible mixture between strata or the presence of multiple occupations. At Maisières, the Aurignacian level is homogeneous, with a single type of flint represented with a similar patina for all artifacts. The flint is Obourg flint, found next to the site in the Cretaceous chalk formations and easily accessible in the eroding chalk flows. The flint is of good quality, black or brown, and translucent with few inclusions; patina is bluish-white and artifacts often became patinated only after being excavated. Artifacts edges and ridges are fresh, indicating little movement.

Several observations can be made:

1. The vast majority of artifacts are found in a dense circular concentration 5–10-cm thick in the lower part of Unit NBD, centered on squares 68–69 A-B, with a smaller adjacent concentration in squares 67–69 Z-A. The base of the concentration follows the unit slope, and is particularly clear in 68–69 A-B. These concentrations are considered to be in place.
2. A few artifacts are found above the main concentration, at the top of NBD and in the lower part of Unit NCA. No refits were possible between these artifacts and the main concentration; however, they are similar in raw material, morphology, and patination. Oblique or vertical, they appear to have been moved by post-depositional freeze-thaw action.
3. In squares 69 Z-A and occasionally in 67–68 A-B, some artifacts are found below the main concentration in the basal part of Unit NBD corresponding to the small initial horizon of the humus-bearing soil. Others are found 10–15 cm lower in Unit NBC. Refitting shows 13 series joining 43 artifacts from the main concentration and the base of NBD, including seven technological series, two tool modifications, and four breaks. Four tools are also part of the refits. These demonstrate the integrity of the assemblage within Unit NBD. No refits were possible between artifacts found in underlying NBC and the main concentration, although they again are morphologically similar.
4. A slightly different situation is observed in squares 70–73 A-C, which show a dispersed distribution of artifacts within NBD and a relatively high number of artifacts dispersed up to 25 cm lower in NBC. Among the artifacts dispersed upslope from the concentration (squares 69–72 C-D), 28 join with artifacts in the main concentration. It is suggested that the upslope dispersal is due to human activities taking place at the site rather than post-depositional disturbance.

The data demonstrate the integrity of the lithic assemblage of Unit NBD, which would appear to be the product of a single phase of activity. Such activity would have occurred during the initial formation phase of the humus-bearing horizon, in an interstadial episode associated with grass cover on the northern slope of the Haine valley. In this context, the distribution of lithic elements in the upper half of the horizon in squares 68–69 Z-B is likely the result of post-depositional freeze-thaw action, as is also indicated by the sub-vertical or oblique position of many artifacts. However, interpretation of the presence of artifacts in the underlying Unit NBC, some reaching 20 cm below the main concentration, remains problematic and could attest to a preceding activity phase.

Structure of the Aurignacian Lithic Assemblage

Table 1 summarizes the composition of the Aurignacian assemblage.

The Aurignacian assemblage contains 44 formal tools (Table 2) as well as a slightly higher number of artifacts with slight retouch or traces of use (n = 74). Busked and carinated burins are included in the list, but are interpreted as bladelet cores rather than tools; 19 tools were able to be refitted, indicating that they were prepared and abandoned onsite.

Numbering 11, burins are the best represented category (25 % of the toolkit). In addition, two other burins, one busked and one dihedral, are

Maisières-Canal: An Open-Air Aurignacian Workshop, Table 1 Maisières-Canal, Trench 2, Aurignacian. Frequencies of types of reduction products (2000–2002 excavations)

Debitage products		n	%
Unclassified		81	2,82
Flakes < 1 cm	Trimming flakes	1,115	38,82
	Bifacial retouch flakes	3	0,10
	Thinning flakes	46	1,60
Debris	Debris < 1 cm	362	12,60
	Angular debris > 1 cm	15	0,52
	Chunks	3	0,10
Blades		486	16.94
Crested blades		18	0,63
Bladelets		49	1,71
Flakes	Flakes	568	19,78
	Laminar flakes	27	0,94
Tablets	Primary tablets	15	0,52
	Secondary tablets	5	0,17
Flanks		8	0,28
Burin spalls		71	2,47
	Total	**2,872**	**100,00**

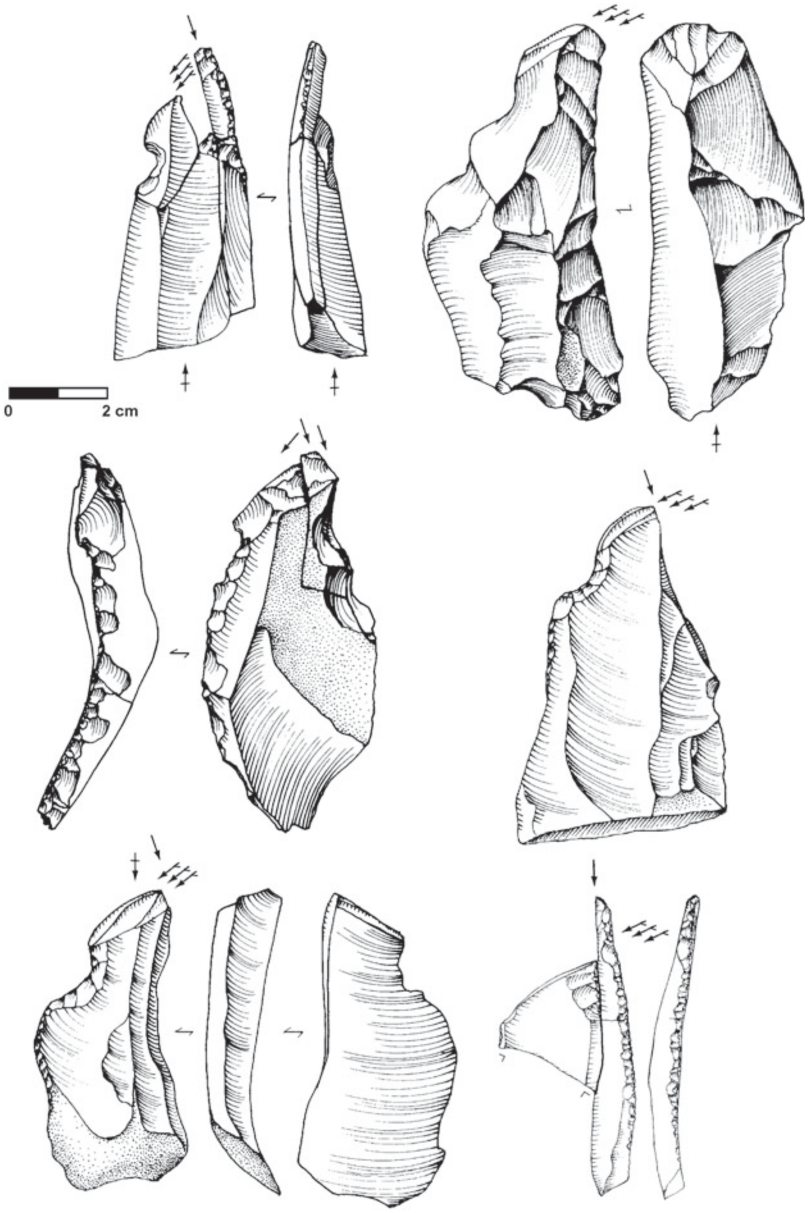
Maisières-Canal: An Open-Air Aurignacian Workshop, Table 2 Aurignacian tool kit

Type	Sub-type	n
Burins		**11**
	Busked	5
	Dihedral	3
	Carinated	1
	Simple	1
	On break	1
Retouched artifacts		**8**
Denticulates		**6**
Notchs		**5**
Endscrapers		**4**
Truncations		**3**
Retouched bladelets	Dufour (Roc-de-Combe)	**1**
Composite tools		**6**
	Busked burin -sidescraper-notch	1
	Dihedral burin –notch	1
	Notch-retouched artifact	4
Total		**44**

included in the category of composite tools. For the busked burins (Fig. 3), a notch on the left edge served to terminate transversal removals (Fig. 4: 9–18). The striking platform for these short removals is on the right edge, formed by the removal of a long burin spall parallel to the longitudinal axis of the burin (Fig. 4: 1–3). Busked burins were made on two partially cortical flakes and a partially cortical blade that were produced during the preparation of blade cores; long burin spalls were able to be refitted to each, indicating that they were prepared at the site. Another busked burin was made on a thick blade, onto which a long burin spall and a flake renewing the notch were refitted, suggesting that the artifact had undergone relatively significant reduction. Finally, a distal fragment of a busked burin, broken at the notch, and a proximal fragment of a longitudinal burin spall were refitted. Three dihedral burins are present, one on a blade retouched on both lateral edges, another on a tablet from a blade core, and a dihedral angle burin on an unretouched blade. Refitting of a longitudinal burin spall with transversal negatives to this last indicates that it had previously been a busked or carinated burin. It should be noted that this is the only piece where transversal removals were removed from the left side. A fourth is classified with the composite tools. The distal fragment of a carinated burin with a longitudinal burin spall refitted to the right edge shows the reduction of at least 1.2 cm of the burin by transversal removals. The left edge of the piece is slightly retouched, but lacks a clear notch; it is thus not classified with the busked burins. A simple burin on a blade refits to a burin spall, but was not used to produce short bladelets similar to those produced from the busked burins.

The total number of bladelets refitted to busked burins is 124. This may appear elevated, but certain refits demonstrate that the burins underwent significant reduction in length and would account for the high number of bladelets recovered as well as reflecting the focus on bladelet production at the site.

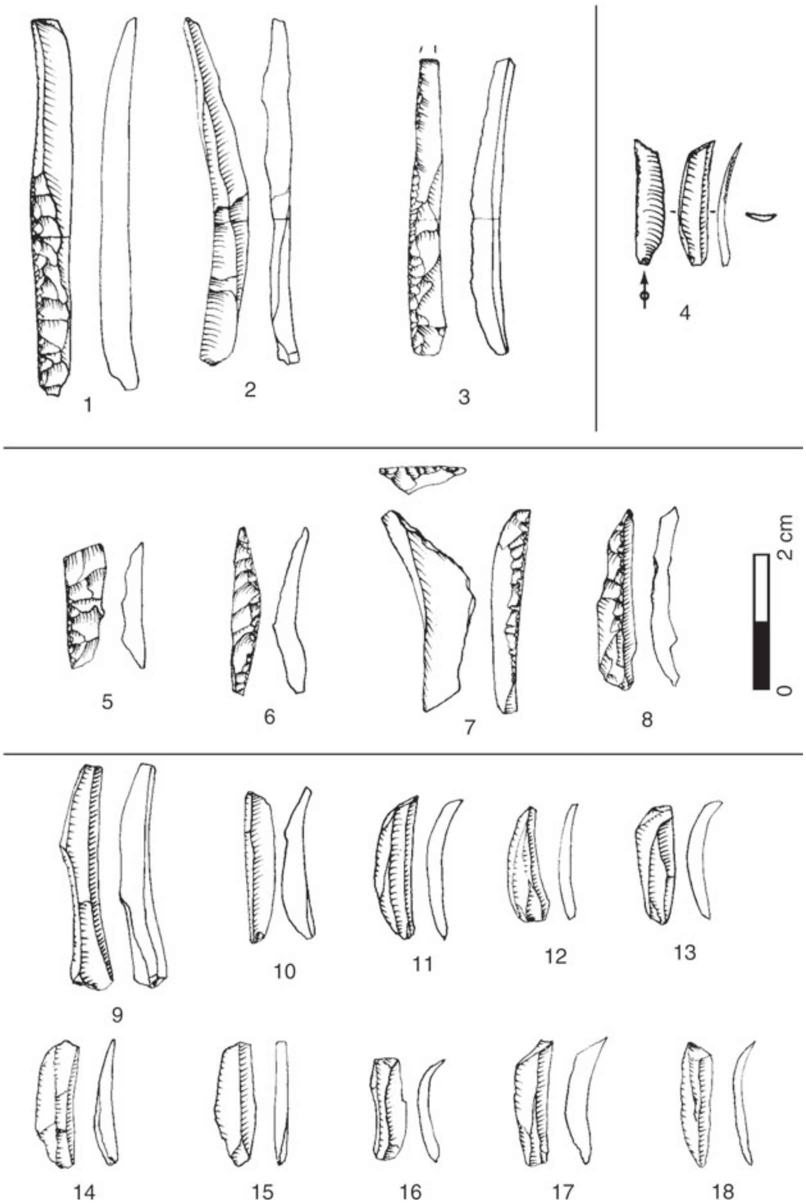
There is a single retouched bladelet, curved and twisted, asymmetric to the right, with very fine inverse retouch on the mesio-distal portion of



Maisières-Canal: An Open-Air Aurignacian Workshop, Fig. 3 Maisières-Canal, Aurignacian, busked burins

the right edge (Fig. 4: 4). Retouch is limited, but regular and seems to have been intentional. Small chips on the distal end correspond, in contrast, to be accidental retouch resulting from bladelet reduction (Lucas 2000; Bordes & Lenoble 2002: 744; Chiotti 2003; Le Brun-Ricalens & Brou 2003). The piece is similar typologically to Dufour bladelets of Roc-de-Combe type, characterized by its small size (Demars & Laurent 1989: 102) and by its twisted aspect. The morphology and size suggest that it was removed as a "spall" from a carinated piece, such as the busked burins present on the site.

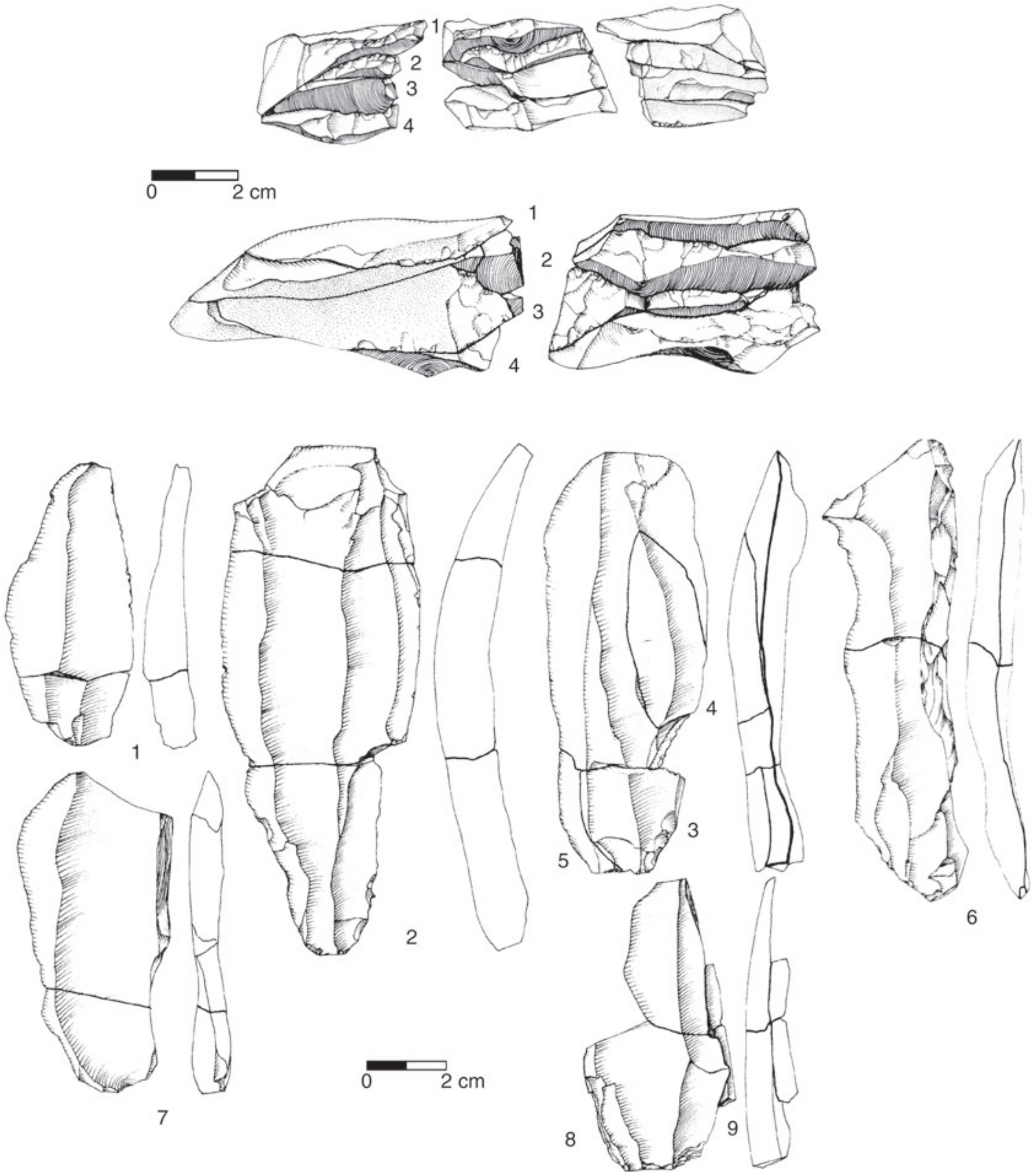
Artifact refitting shows the focus on bladelet production onsite, as well as the preparation of blade cores for export (Fig. 5). Different reduction phases are also demonstrated, including decortication, core preparation, blade/bladelet production, and the removal of crested blades.



Maisières-Canal: An Open-Air Aurignacian Workshop, Fig. 4 Maisières-Canal, Aurignacian, burin spalls and bladelets. (**1–3**) long burin spalls to prepare striking platform for short bladelets. (**4**) retouched bladelet (Dufour of Roc-de-Combe type). (**5–8**) retouched burin spalls. (**9–18**) bladelets

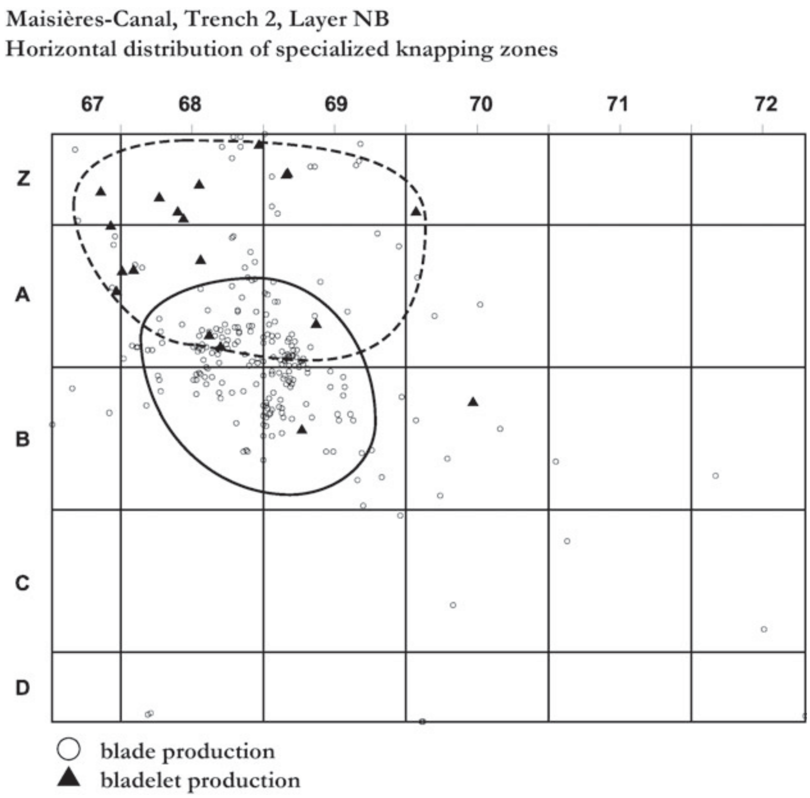
Specialized Activity Zones

Two activity zones were identifiable on the basis of the spatial distribution of technological refits and tool modifications (Fig. 6). The main concentration in squares 68–69 A-B is identified by the presence of technological refit series and unrefitted artifacts from all reduction phases: cortex removal, core preparation (series n° 2, 10, 11), preparation of crested blades (series n° 4, 74), removal of tablets during blade production (series n° 6, 8), and blade production (series n° 100). The vast majority of microdebris and small flakes are also found in squares 68A (n = 725) and 69A (n = 407) in comparison with squares 68B (n = 42) and 69B (n = 92); they are rare in the rest of the site. By contrast, bladelet production from burins is shown by refits of bladelets and burins, as well as numerous unrefitted bladelets, found concentrated slightly outside this zone, in squares 68–69 Z-A. All of the busked burins are



Maisières-Canal: An Open-Air Aurignacian Workshop, Fig. 5 Maisières-Canal, Aurignacian, *top*: two series of refitted core rejuvenation tablets from blade cores; *bottom*: refitted blades

found in squares 67Z, 69Z, and 68A, each refitted to a long burin spall creating the striking platform for bladelet production, while burins on break and dihedral burins are found in 68A-B and 69-70B. Technological activity associated with the busked burins thus took place in a 2 m^2 zone adjacent to the main reduction area. The second zone, then, would appear to have been specialized for bladelet production. Thus, even in a zone fairly restricted in area (around 7 m^2), two specialized activity zones can be distinguished, one focusing on the preparation of flint blade cores and blade production, the other associated with busked burins and bladelet production.



Maisières-Canal: An Open-Air Aurignacian Workshop, Fig. 6 Maisières-Canal, Aurignacian, specialized knapping zones for blade and bladelet production

Interpretation

The structure of the Aurignacian lithic assemblage and its spatial distribution clearly demonstrate the function of the site as a flint workshop of short duration, for the preparation of blade cores and bladelets for export elsewhere. All of the reduction phases are represented. Tools, while rare and opportunistic, were produced on reduction by-products and not generally on intentional blanks (blades and bladelets). They were likely used for activities during the short-term occupation, reserving any blanks produced for export. The area of the site is small, around 25 m^2 excluding the part of the site destroyed by recent development along the canal.

There is no evidence of hearths or dwelling structures. Apart from the two adjacent knapping zones, there is no evidence for other activities that may have taken place during the occupation. Little fauna is preserved (e.g., a reindeer molar), certainly due to the open-air loess context, but this may also reflect a limited degree of hunting during the occupation.

The Aurignacian workshop thus contrasts in many ways to the Gravettian occupation, which contained hearths, abundant fauna, evidence of butchering activity, the presence of bone tools, and a higher degree of flint reduction activity onsite.

The interpretation of the site is thus that it served as a short-term workshop, perhaps only for a few days, focused on bladelet production and the preparation of blade cores, with few "domestic" activities that would be associated with a longer-term camp. The lithic assemblage appears to have resulted from a single occupation, ultimately with the export of blade cores and blade/bladelet blanks and tools for use at other sites.

Cross-References

► Europe: Early Upper Paleolithic

References

BORDES, J.-G. & A. LENOBLE. 2002. La “lamelle Caminade”: un nouvel outil lithique aurignacien? *Bulletin de la Société Préhistorique Française* 99(4): 735–49.

BASTIN, B. 1971. Recherches sur l'évolution du peuplement végétal en Belgique durant la glaciation du Würm. *Acta Geographica Lovaniensia* 9: 1-136.

CHIOTTI, L. 2003. Les productions lamellaires dans l'Aurignacien de l'Abri Pataud, Les-Eyzies-de-Tayac (Dordogne). *Gallia Préhistoire* 45: 113–56.

DE HEINZELIN, J. 1971. Le gisement Périgordien de Maisières-Canal (1966). *Bulletin de la Société royale belge d'Anthropologie et de Préhistoire* 82: 63–76.

- 1973. *L'industrie du site paléolithique de Maisières-Canal* (Mémoires 171). Bruxelles: Institut Royal des Sciences Naturelles de Belgique.

DEMARS, P.-Y. & P. LAURENT. 1989. *Types d'outils lithiques du Paléolithique supérieur en Europe* (Cahiers du Quaternaire 14). Paris: Editions du CNRS.

DEWEZ, M. (ed.) 2008. *Recherches à la grotte Walou à Trooz (Belgique)/Studies in Walou Cave in Trooz (Belgium). Second rapport de fouille/Second excavation report* (British Archaeological Reports International series S1789). Oxford: Archaeopress.

FOURNY, M. & M. VAN ASSCHE. 1992. Sites aurignaciens en surface autour du Bois de la Houssière, Braine-le-Comte, Ecaussines d'Enghien, Henripont et Ronquières (Hainaut). *Notae Praehistoricae* 11: 29–31.

GILOT, E. 1971. Louvain natural radiocarbon measurements. *Radiocarbon* 13(1): 45-51.

HAESAERTS, P. 1973. Contribution à la stratigraphie des dépôts du Pléistocène supérieur du bassin de la Haine. Unpublished PhD dissertation, Vrije Universiteit Brussel.

- 1974. Séquence paléoclimatique du Pléistocène supérieur du bassin de la Haine (Belgique). *Annales de la Société Géologique de Belgique* 97: 105–37.

- 2000. Geology and chronostratigraphy, in L.G. Straus, M. Otte & P. Haesaerts (ed.) *La station de l'Hermitage à Huccorgne. Un habitat à la frontière septentrionale du monde gravettien* (ERAUL 94): 15–34. Liège: Université de Liège.

HAESAERTS, P. & J. DE HEINZELIN. 1979. *Le site palé olithique de Maisières-Canal* (Dissertations Archaeologicae Gandenses 19). Brugge: De Tempel.

HAESAERTS, P., H. MESTDAGH & D. BOSQUET. 1999. The sequence of Remicourt (Hesbaye, Belgium): new insights of the pedo- and chronostratigraphy of the Rocourt Soil. *Geologica Belgica* 2(3–4): 5–27.

HAESAERTS, P. & B. VAN VLIET. 1974. Compte rendu de l'excursion du 25 mai 1974 consacrée à la stratigraphie des limons aux environs de Mons. *Annales de la Socié té Géologique de Belgique* 97: 547–60.

HAESAERTS P. & B. VAN VLIET-LANOË. 1981. Phénomènes périglaciaires et sols fossiles observés à Maisières-Canal, à Harmignies et à Rocourt. *Biuletyn Peryglacjalny* 28: 291–324.

HAHN, J. 1977. *Aurignacien, das ältere Jungpaläolithicum in Mittel- und Osteuropa* (A (9)). Köln: Fundamenta.

JACOBI, R., T.F.G HIGHAM, P. HAESAERTS, I. JADIN & L.S. BASELL. 2010. Radiocarbon chronology for the early Gravettian of northern Europe: new AMS determinations for Maisières-Canal, Belgium. *Antiquity* 84: 26–40.

LE BRUN-RICALENS, F. & L. BROU. 2003. Burins carénés-nucléus à lamelles: identification d'une chaîne opératoire particulière à Thèmes (Yonne) et implications. *Bulletin de la Société Préhistorique Française* 100(1): 67–83.

LUCAS, G. 2000. Les industries lithiques du Flageolet I (Dordogne). Approche économique, technologique, fonctionnelle et analyse spatiale. Unpublished PhD dissertation, Université de Bordeaux I.

MILLER, R., P. HAESAERTS & M. OTTE (ed.) 2004. *L'Atelier de taille aurignacien de Maisières-Canal, Belgique* (ERAUL 110). Liège: Université de Liège.

MILLER, R., M. OTTE, J. HAECK, F. COLLIN & I. LÓPEZ BAYÓN. 1998. The Grotte du Docteur: preliminary report for the 1998 excavations. *Notae Praehistoricae* 18: 65–75.

OTTE, M. & L.G. STRAUS. (dir.) 1995. *Le Trou Magrite. Fouilles 1991-1992. Résurrection d'un site classique en Wallonie* (ERAUL 69). Liège: Université de Liège.

OTTE, M. & R. MILLER. 2000. La Grotte du Docteur à Moha. *Quatrième Journée d'Archéologie Liégeoise* 27: 45–55.

TERBERGER, T. & M. STREET. 2003. New evidence for the chronology of the Aurignacian and the question of Pleniglacial settlement in western central Europe, in F. D'Errico & J. Zilhao (ed.) *The chronology of the Aurignacian and of the transitional technocomplexes. dating, stratigraphies, cultural implications. Proceedings of Symposium 6.1 of the XVth Congress of the U.I.S.P.P. Liège, Belgium September 2001* (Trabalhos de Arqueologia 33): 213–21. Lisbon: Instituto Português de Arqueologia.

TOUSSAINT, M., S. PIRSON, I. LÓPEZ BAYÓN, A. BECKER, Ph. LACROIX & S. LAMBERMONT. 1999. Bilan préliminaire de trois années de fouilles à l'Abris Supérieur de Goyet (Gesves, province de Namur). *Notae Praehistoricae* 19: 39–47.

VAN DER HAMMEN, T. 1995. The Dinkel Valley revisited: Periglacial stratigraphy of the eastern Netherlands and global climatic change. *Mededelingen Rijks Geologische Dienst* 52: 343–55.

VOGEL, J. & T. VAN DER HAMMEN. 1967. The Denekamp and Paudorf interstadials. *Geologie en Mijnbouw* 46: 188–94.

Further Reading

OTTE, M. (ed.) 1992. *Recherches aux grottes de Sclayn, Volume 1: Le contexte* (ERAUL 27). Liège: Université de Liège.

OTTE, M. & L.G. STRAUS (ed.) 1992. *Le Trou Magrite: Fouilles 1991–1992: Résurrection d'un site classique en Wallonie. Resurrection of a classic site in Wallonia*

(1991–1992 excavations) (ERAUL 69). Liège: Université de Liège.
Otte, M., M. Patou-Mathis & D. Bonjean (ed.) 1998. *Recherches aux grottes de Sclayn, Volume 2: L'arché ologie* (ERAUL 79). Liège: Université de Liége.
Pirson, S., C. Draily & M. Toussaint. 2011. *La grotte Walou à Trooz (Belgique): fouilles de 1996 à 2004*, (3 volumes). Namur: Institut du Patrimoine, coll. Études et Documents.
Straus, L.G., M. Otte & P. Haesaerts. (ed.) 2000. *La Station de l'Hermitage à Huccorgne: un habitat à la frontière septentrionale du monde gravettian. The open-air Hermitage site at Huccorgne: an open-air site at the northern frontier of the Gravettian world* (ERAUL 94). Liège: Université de Liége.

Maize: Origins and Development

Tim Denham
Archaeological Science Programs, School of Archaeology and Anthropology, ANU College of Arts and Social Sciences, The Australian National University, Canberra, ACT, Australia

Basic Species Information

Today, maize (*Zea mays* L.), which is also called "corn" or "sweet corn" in English-speaking countries, is one of the most important food crops cultivated globally. From initial, potential domestication in the Balsas River Valley of tropical southwestern Mexico around 9,000–8,600 years ago (Piperno et al. 2009), maize spread across much of Central and South America before 4,000–3,000 years ago (Iriarte 2007), to North America around 2,000 years ago (see Fritz 2007), and has subsequently dispersed across the globe in the last 500 years or so.

Today, maize is grown by subsistence farmers across the globe as a source of starch or carbohydrate. Its widespread geographical adoption is due to its ability to adapt to a variety of climates, soils, and habitats. Although an important food crop, it is also grown for ethanol and corn syrup; the latter is a contributor to a vast array of processed foods.

The multidisciplinary history of maize domestication and dispersal is comparatively well-defined through archaeobotany (macrofossils and microfossils) and genetics (DNA and aDNA). Multidisciplinary research has enabled the processes of human selection and resultant morphogenetic transformation in the generation of maize to be tracked, as well as domestication traits that are not visible in the archaeobotanical record (Jaenicke-Després et al. 2003; Doebley et al. 2006; Zeder et al. 2006).

Major Domestication Traits

Genetic research has shown that maize is descended from a wild grass teosinte (*Zea mays* ssp. *parviglumis* or Balsas teosinte) that is native to the Balsas River Valley in tropical southwestern Mexico (Matsuoka et al. 2002). Domestication resulted in the transformation of multiple traits in teosinte to create maize. These include archetypical traits of the domestication syndrome in grasses, such as size of edible glume (much larger in maize) and nonshattering rachis (in maize), as well as other traits, such as apical dominance (replacement of multiple stalks with single stalk) and kernel case formation (enclosed casing around kernel in teosinte). Genes have been identified that control specific morphological changes, or domestication traits in maize, including *Teosinte branched 1* (*tb1*, apical dominance) and *Teosinte glume architecture 1* (*tga1*, kernel casing), as well as genes that control varietal differentiation based on kernel color, composition, and sweetness (Doebley et al. 2006; Zeder et al. 2006).

In 2001, Piperno and Flannery (2001) reported two archaeological cobs of maize dated to c. 6300–6000 cal BP from Guilà Naquitz Cave in the Oaxaca Valley of Mexico. These cobs exhibited all the major morphological characteristics of domesticated maize (Benz 2001), suggesting that domestication had already taken place. More recent archaeological research at Xihuatoxtla Shelter in the Central Balsas River Valley has identified starch grains and phytoliths of maize on stone artifacts and in associated sediments dating back to c. 9000–8600 cal BP (Piperno et al. 2009; Ranere et al. 2009). These finds indicate that maize was domesticated early