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The 'Palaeolithic Prospection in the Inde Valley' Project

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Abstract: The excavation of 20 deep test trenches of Pleistocene layers in the quarry Inden between Jülich-Kirchberg and Lamersdorf in 2005 and 2006 was part of the 'Palaeolithic Prospection in the Inde Valley' Project of the Foundation "Stiftung Archäologie im Rheinischen Braunkohlenrevier". They were aimed at finding and unearthing ancient landscape surfaces and potential Palaeolithic settlement structures. In December 2005, a Middle Palaeolithic archaeological layer correlating to the Eemian interglacial was discovered. This layer was investigated and excavated until September 2006 within an area of 3000sqm. About 700 lithic artefacts and pebble manuports were found together with evident features of pits and hearths. Three fallen-tree structures were situated in the center of the major concentration of artefacts and were probably part of the habitation.

The discovered artefacts showed no signs of re-deposition or secondary transport and still maintained their original surface structure and sharp edge with no or minor patination. They were very suitable for the successive microscopic use-wear analysis which delivered a variety of remarkable and outstanding results. Various microwear traces and residues were found on a total of 120 stone tools out of 136 artefacts selected for analysis. The residues were identified through SEM and EDX as birch pitch. 82 tools were either used as hafted impliments and fixed with birch pitch onto shafts or were being used for successive hafting-and-retooling activities. Birch pitch is the oldest synthetically produced material and is commonly associated with modern humans in the Upper Palaeolithic. The birch pitch residues found on the Micoquien tools of Inden suggest that hafting technologies, use of adhesives and multicomponent tool making already existed in the Middle Palaeolithic. The complex actions involved in composite-tool making indicate clearly modern human behaviour.

[Prospektion Paläolithikum im Indetal]

Kurzfassung: Im Rahmen des Projektes „Prospektion Paläolithikum im Indetal" der Stiftung Archäologie im Rheinischen Braunkohlenrevier wurden in den Jahren 2005 und 2006 im Tagebau Inden zwischen Jülich-Kirchberg und Lamersdorf die pleistozänen Deckschichten mittels 20 Baggertiefschnitten sondiert. Ziel war es, fossile Landoberflächen und mögliche paläolithische Siedlungsplätze zu finden und freizulegen. Im Dezember 2005 konnte in der Ortslage Inden-Altdorf eine mittelpaläolithische Fundschicht aus dem Eem-Interglazial entdeckt werden, die bis September 2006 auf einer Fläche von 3000 m² archäologisch untersucht werden konnte. Es fanden sich 700 Steinartefakte und herbeigebrachte Gerölle, aber auch evidente Grubenbefunde und Feuerstellen. Drei Baumwürfe lagen mitten in der Hauptartefaktkonzentration und waren wohl in das Siedlungsgeschehen eingebunden. Die Artefaktoberflächen waren kantenscharf und nicht patiniert, so dass die durchgeführten Gebrauchsspurenanalysen außergewöhnlich erfolgreich waren. Auf 120 der insgesamt 136 für die Gebrauchsspurenanalyse ausgewählten Artefakte fanden sich Mikrospuren verschiedenartiger Tätigkeiten sowie Residuen. Diese konnten mittels Rasterelektronenmikroskopie und energiedispersiver Röntgenmikroanalyse als Reste von Birkenrindenpech identifiziert werden. 82 Geräte mit Residuen erwiesen sich entweder als geschäftete Einsätze, die mit diesem Pech an den Schäften befestigt wurden oder als Werkzeuge für die Reparatur von gebrauchten und mit Pech verklebten Schäftungen, und dem Auswechseln verbrauchter Feuersteineinsätze dienten. Birkenrindenpech kann als ältester synthetisch hergestellter Werkstoff angesehen werden und wird in der Regel mit dem Jungpaläolithikum und modernen Menschen assoziiert. Die auf den Micoquien Artefakten aus Inden vorgefundenen Birkenpechreste zeigen, daß sowohl Schäftungstechnologien, Gebrauch und Herstellung von Klebstoff als auch die Anfertigung von komplexen, aus mehreren Komponenten bestehenden Geräten im Mittelpaläolithikum durchaus üblich waren. Deren Vorhandensein, noch dazu in einer vergleichsweise hohen Anzahl, kann als deutlicher Hinweis auf moderne menschliche Verhaltensweisen gewertet werden.

Keywords: *Micoquian, Eemian, habitation features, microwear analysis, hafting, birch pitch residues, behavioural modernity*

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1 Introduction

A sharp-edged, blue-and-white patinated middle palaeolithic handaxe found at the open-cast lignite mine Inden (in the area of Geuenich) urged one of the authors (JTh) in July 2004 to inspect this locality (Päffgen & Thissen 2005). The handaxe derived from a loess horizon correlating to the Weichselian period under which a fossil soil layer most likely correlating to the Eemian period (OIS 5e 128.000–115.000 BP) was localized. An early Pleistocene Maas terrace is cropping out between the Inde and Wurm valley, carrying large quantities of flint pebbles from the Dutch-Belgian "Kreideflint" region. Where the Maas terrace was exposed on the surface during the Pleistocene, Palaeolithic flint-knapper had an attractive and unlimited supply of raw material.

Several hand-axes and half-finished products were found, mainly by F. Schmidt (Aldenhoven), who is field-walking in this area since the mid 1970s. This open site, closely located to the Maas terrace, was identified as a workshop ("Atelier") of the Micoquien period (Thissen 2006). This promis-

Fig. 1: Map of Germany with the location of the site Inden-Altdorf.
Abb. 1: Deutschlandkarte mit der Lage des Fundplatzes Inden-Altdorf.

ing topographical situation, which archaeologically seems to indicate a favoured area, led to the proposal of a survey project to the **Foundation "zur Förderung der Archäologie im Rheinischen Braunkohlenrevier"** that was granted in March 2005. The grant included the comprehensive lithic analysis of the archaeological finds. Additional to the morphological and technological assessment of the lithic materials, microscopic use-wear and residue analysis was conducted. In a pioneering study for the Middle Palaeolithic of the region, all modified tools and selected unmodified pieces underwent optical high and low power analysis as well as residue analysis using scanning electron microscopy and energy-dispersive X-ray microprobing.

2 Palaeolithic Prospection in the Inde Valley

2.1 Test excavations at Inden and Altdorf 2005

Several previous surveys of the embankment of the mining areas of Garzweiler and Inden were conducted to locate Middle or Upper Palaeolithic settlements but remained rather unsuccessful. In 1987 the Mesolithic site Bedburg-Königshoven was found at the Garzweiler mine (Thissen 1997), after a skull and antler of deer were discovered in the wall of the open cast pit. The archaeological layer was close to the surface below a turf layer in a silted-up meander of the Erft river.

According to experience, sites in loess deposits or in fossil soils are only found by widespread investigations of the Pleistocene landscape. Hence, the Inde Valley Project (Fig. 1) was explicitely designed to reveal palaeosurfaces with heavy equipment, specifically where the characteristic "Eemian soil" indicated an actual fossil surface.

A mechanical excavator set up a series of deep test trenches, first around the area of Inden in 2005 on the west bank of the river (WW 2005/51) that was under threat by the ongoing and approaching mining activities. These trenches were app. 2.5 to 4.5 metres wide, up to 4–6 metres deep and up to 75 metres long. In August and November 2005 seven deep test trenches (DT) were opened there, revealing the Weichselian loess and possible Eemian layers.

In the trenches nos. 1 to 5, 14 and 15 (see Fig. 2a and Table 1) different stratified sequences were documented. Coincidentally, the Roman Inde valley road from the Augustian period was discovered in the extension of Trench 1. The Pleistocene sediments in the trenches nos. 1, 2, 4 and 5 are generally well preserved, but neither Palaeolithic artefacts nor archaeological features could be found. It was also not possible to locate the Eemian soil. In the flooded Go/Gr layers of the presumable Eemian period river valley brown patinated silices were found, but all unworked. Trench no. 3 revealed gravels from the main terrace of the Rhine together with Tertiary deposits. Trenches no. 14 and no. 15 were situated in an erosive channel underneath the Geuenich hand-axe site. No redeposited Middle Palaeolithic tools were found.

Four other deep trenches at Altdorf (WW 2005/52) excavated to a depth of 8.4 m turned out to be more promising. An eroded brownish red soil, most likely Eemian sediments, and the first redeposited artefacts of Upper Palaeolithic as well as Middle Palaeolithic age were discovered.

2.2 Discovery of the Eemian artefact layer

Following the discovery of Eemian soils and nearby old, brown patinated lithic artefacts at Altdorf, a (last) test excavation (WW 2005/91) for this survey project was carried out.

In October 2005, the first Eemian soil in situ was observed in Trench no. 11. In Trench no. 12, opened at the former corner of Altdorf's Gartenstrasse and Chlodwigstrasse, an Eemian Bt horizon and the Maas terrace sediments were finally located in direct contact. This was the sought-after, potentially ideal position for a settlement of Palaeolithic groups during the Eemian-Interglacial. There, the Maas gravels were exposed by erosion forming a channel in north-eastern direction ("Altdorfer Tälchen") into the Inde valley. Trench no. 13, excavated in December 2005 delivered the first archaeological evidence: in a slightly re-deposited Al-horizon three non-patinated Middle Palaeolithic artefacts made of Maas flint were uncovered underneath a loess deposit of three metres thickness (Fig. 3). Based on this promising result, the Inde Valley Project could be extended for one more year to thoroughly study the new site.

2.3 Excavation of the Middle Palaeolithic open site Altdorf (WW 124)

In 2006 the research activities focussed on WW 2005/91 and WW 2006/74. Systematic probing of the area around the Middle Palaeolithic finds at Altdorf started in the beginning of January 2006. Initially, the excavation was done conven-

Tab. 1: Palaeolithic Prospection in the Inde Valley, deep trenches 1–20.

Tab. 1: Prospektion Paläolithikum im Indetal, Baggertiefschnitte 1–20.

Deep trench (Feature)	m ASL	Ah/Ap	Bt	Sediments (1)	Sediments (2)	Sediments (3)	Sediments (4)
Inden							
1 (2 u. 6)	107.73	x		Roman disturbance until 1.6 m	Weichselian loess until 4 m	Go/Gr (Eemian) until 4.5 m	Saalian gravel until 4.6 m – B
2 (8)	107.76	x	x		Weichselian loess until 4 m	Go/Gr (Eemian) until 4.5 m	Saalian gravel until 4.6 m – B
3 (9)	107.09	x				Rhein-HT until 1.5 m	Tertiär until 4.5 m – B
4 (10)	107.15	x	x		Weichselian loess until 3.8 m	Go/Gr (Eemian) until 4.5 m	Saalian gravel until 4.6 m – B
5 (11)	108.25	x	x		Weichselian loess until 3.8 m	Go/Gr (Eemian) until 4.5 m	Saalian gravel until 4.6 m – B
14 (12)	104.17			Colluvium	Alluvial loess until 3 m – B		
15 (24)	104.56			Colluvium	Alluvial loess until 3 m – B		
Altdorf							
6 (14)	109.53			Holocene disturbance until 0.8 m	Weichselian loess until 1.6 m	Weichselian loess, sand and dislocated (?) Eemian Bt until 5.9 m	Sand and gravel until 6.1 m – B
7 (15)	110.27	x		Colluvium	Weichselian loess and sand until 5.3 m	Dislocated (?) Eemian-Bt until 6.0 m	Saalian loess until 6.4 m – B
8 (16)				Colluvium until 2.5 m – B			
9 (17)	115.22	x	x		Weichselian loess, gravel and sand until 2.7 m	Dislocated (?) Eemian-Bt until 3.5 m	Saalian gravel until 3.75 m – B
10 (19)	107.13			Colluvium, roman Street, atlantic soil until 2.8 m	Alluvial loess until 3 m – B		
11 (21)	110.78				Weichselian loess until 0.9 m	Eemian-Bt in situ until 1.8 m	Saalian loess until 5.0 m – B
12 (22)	113.50	x		Colluvium	Weichselian loess until 1.8 m	Eemian-Bt in situ until 3.4 m	Maas terrace until 3.6 m – B
13 (23)	113.29	x			Weichselian loess until 3 m	Dislocated Al-horizon (Eem)	Eemian-horizon in situ until 4.0 m – B
16 (50)	111.32	x	x		Weichselian loess until 5.60 m	Eemian-Interglacial-Complex, OIS 5a - 5e until7.20 m	Saalian loess until 8.4 m – B
17 (3)	105.60	x		Colluvium until 1.3 m	Weichselian loess until 3.3 m	Weichselian loess and eroded Eemian soil until 5.4 m	Saalian loess until 5.6 m – B
18 (4)				3–4 mundocumented, surface profil section 102.05 m	Weichselian loess until 0.6 m	Eroded Al- and Bt-horizon until 1.5 m	Go/Gr (Eemian?) until 3.15 m – B
19 (6)				2-3 m un documented, surface profile section at the river bank 99.30 m	Weichselian loess until 0.15 m	Eroded Al- and Bt-horizon, underneath Eemian gley until 1,05 m	Saalian gravel until 1.25 m – B
20 (2)	102.05				Weichselian loess until 3.4 m	Gley until 3.6 m	Saalian gravel until 4.0 m – B

(– B: Trench bottom)

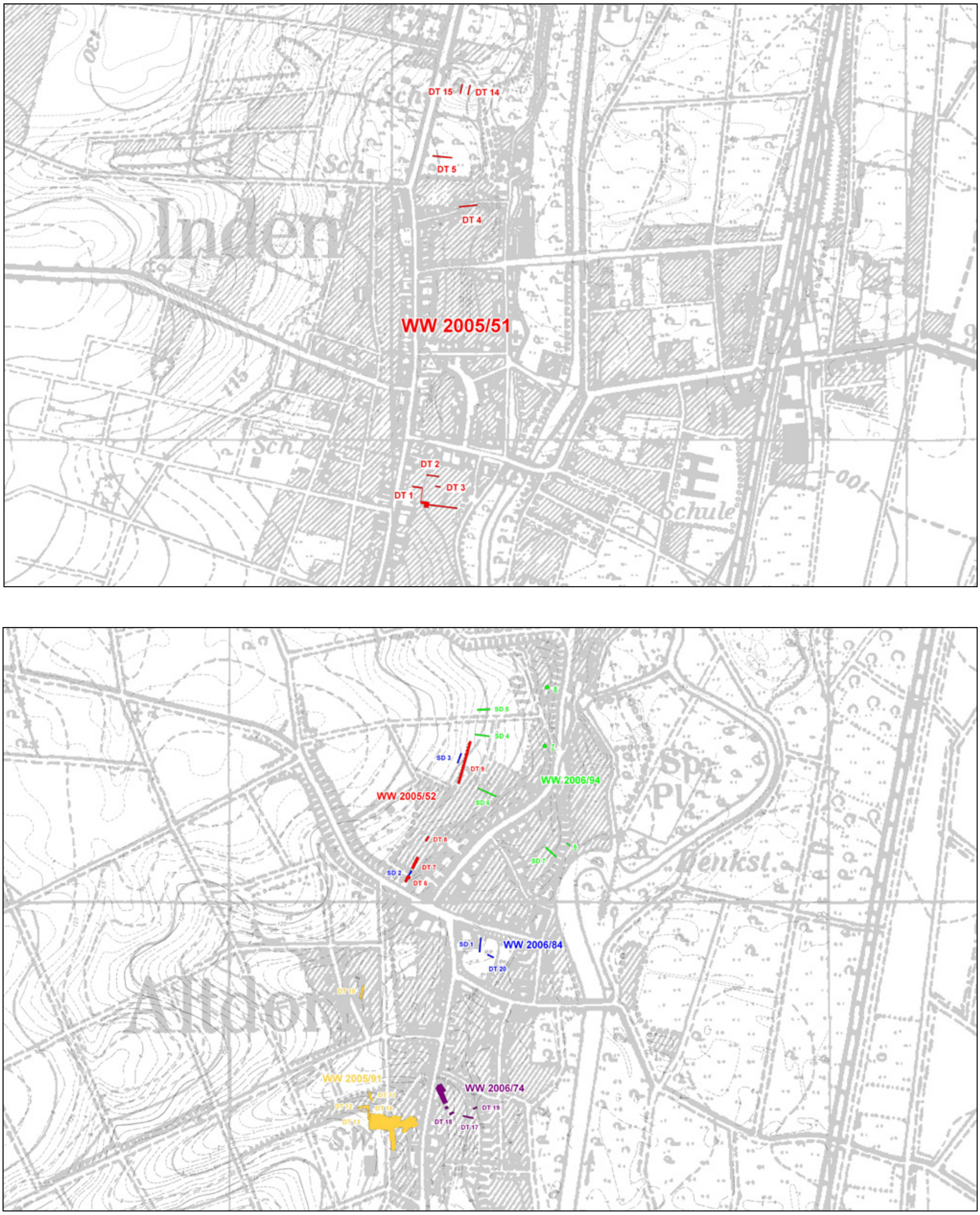


Fig. 2: The position of the trial trenches, sondages and profile sections in a) Inden, b) Altdorf.

Abb. 2: Lage der Baggertiefschnitte, Sondagen und Profilabschnitte in a) Inden, b) Altdorf.

tionally in 1x1m units using spades and trowels. All artefacts recovered in situ were 3-D measured and documented. The excavated sediments were then sieved. However, only 12 small and unmodified artefacts were found in the investigated area of 50 square metres (Fig. 4, Feature 23) by a team of 2 to 3 excavators over a period of 12 weeks. This was far off the aim of the project to localise the Middle Palaeolithic sites. Therefore, it became necessary to adopt methods that could handle excessive amounts of sediments. The Eemian horizon could be carefully machine-excavated using a backhoe. The eastern slope seemed to be suitable for a settlement place, due to a wider view over the valley and the proximity of the river.

Fig. 3: Three flakes from the excavation WW 2005/91.

Abb. 3: Drei Abschläge von der Ausgrabung WW 20095/91.

In March 2006, the excavation of Trench no. 16 started to investigate the eastern slope (Fig. 4, Feature 50). Geology and stratigraphy of this area were documented in the stepped profile of Feature 70 (Fig. 5). Further soil samples and a lacquer profile section were taken from the southern edge of the slope (Fig. 4 and 6; Feature 125, see Kels et al. 2009).

Only few lithic artefacts were found within Feature 50, therefore the trench was extended to the south. Here, the archaeological layer was underneath about 6 metres of loess. There a first fireplace was discovered (Fig. 4, Feature 65) whereas the Al-horizon was sitting directly upon a Bt horizon, both correlating with the Eemian. The character of this feature was not fully understood, then, also because the Al-horizion of the upper slope showed large sections of charcoal specks. The possibility of forest fires causing the presence of charcoal rather than anthropogenic activities had to be considered. However, at the end of April a second fire place was uncovered (see Feature 90), and a significant concentration of artefacts came up within a long excavation trench in southern direction by the end of July (see Feature 180).

At the same time, the first evidence of pits being features was investigated (eg. Fig. 4, Feature 200). They appeared as lighter fillings in the reddish-brown Bt-horizon. The spoilheaps were rapidly getting bigger hampering the excavations. The prolongation of the excavation's duration permitted the enlargement of the excavated area and the transfer of the spoil to reach the new areas of interest (Fig. 6).

Furthermore, a larger artefact concentration was found inside the last extension of the diggings to the east (west of Jülicherstrasse), which at last turned out to be the Middle Palaeolithic camp we were seeking for.

From August 10 to 31, 2006, three large round features were found beside each other (Feature 240, 300 and 330, Fig. 4), clearly distinguishable from the surrounding reddish-brown soil by their light-colored sediment filling (Al-horizon), along with more fireplaces and pits. It became evident, that these were hollow fallen-tree structures (see

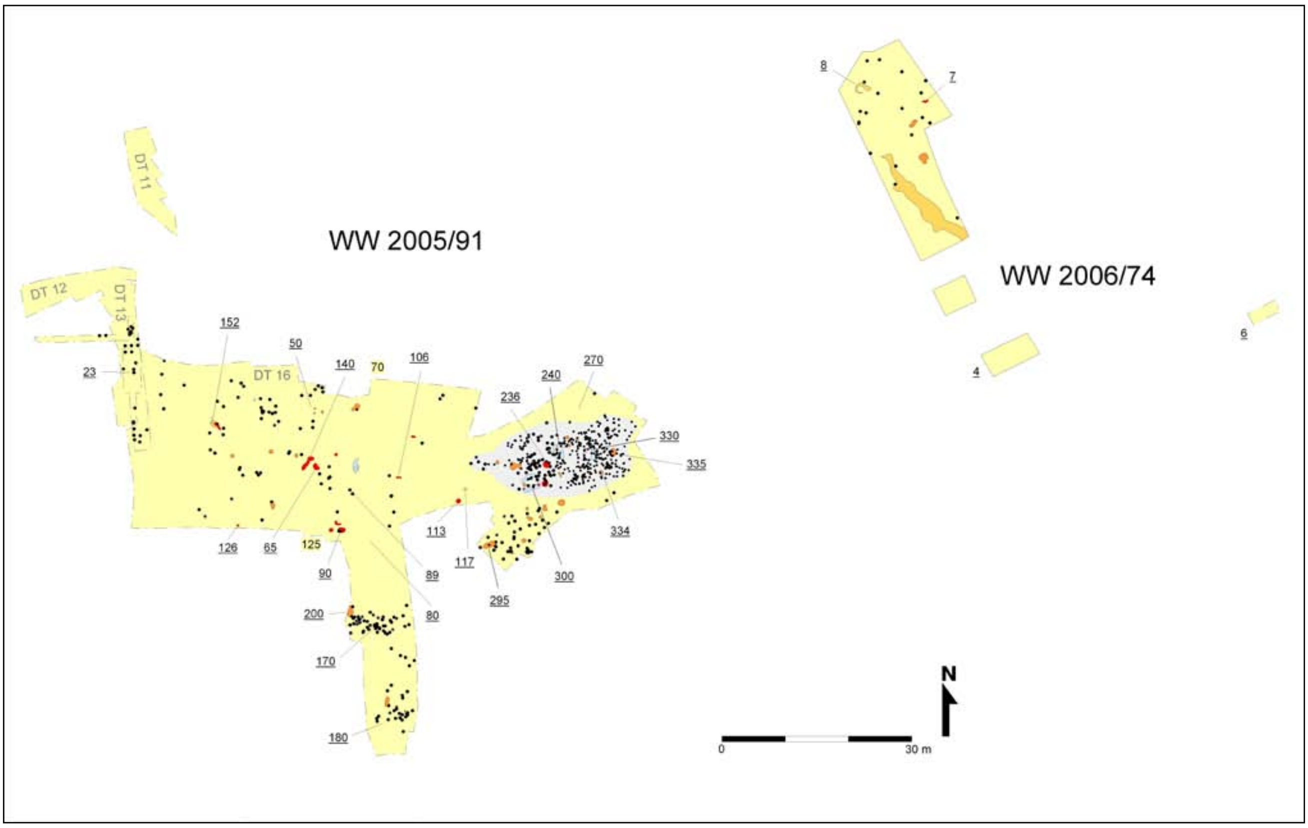
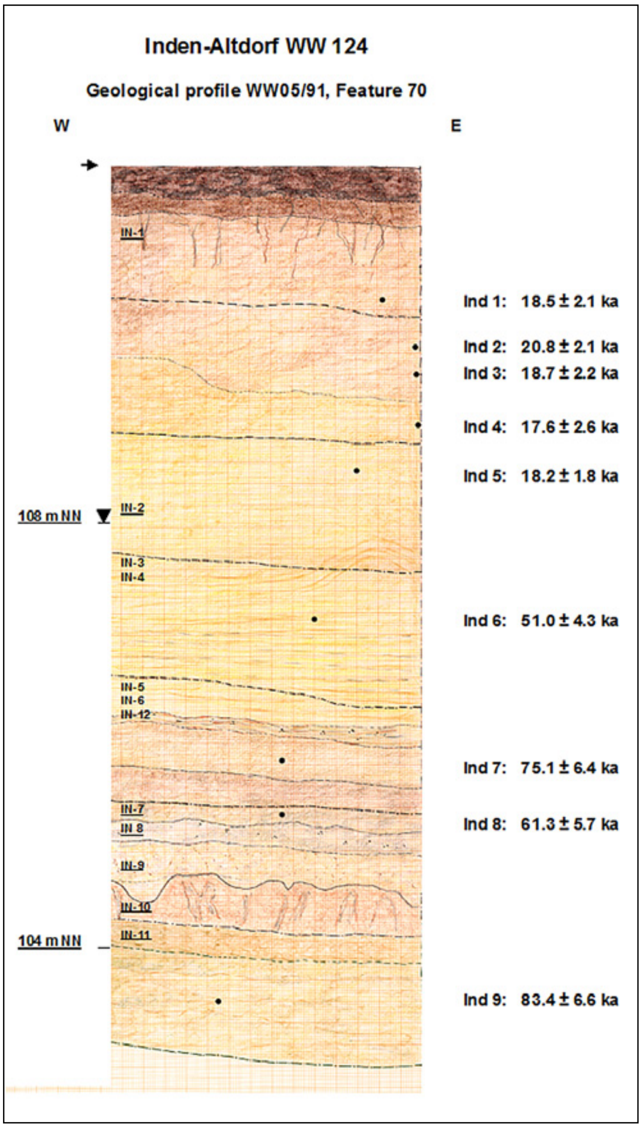


Fig. 4: General plan of the excavation WW 124 (Altdorf) with the activities WW 2005/91 and WW 2006/74 and the most important finds & features. Key: Excavation area (beige), Artefacts & stones (black dots), Pits (brown), fireplaces (red), concentration of artefacts in the camp (light grey) and Huts/Shelters (light blue).

Abb. 4: Gesamtplan der Ausgrabung WW 124 (Altdorf) mit den Aktivitäten WW 2005/91 und WW 2006/74, und die wichtigsten Funde und Befunde. Legende: Grabungsbereiche (beige), Artefakte und Gerölle (schwarze Punkte), Gruben (braun), Brand- u. Feuerstellen (rot), Artefaktkonzentration im Camp (hellgrau) und Hütten/Shelter (hellblau).



Probe	Beschreibung
IN 1	Lösslehm, MBt, rezent verlagert
IN 2	Brabant-Löss, in situ
IN 3	Gebleichter Löss, Eben-Zone (?)
IN 4	Gebleichter Löss, Eben-Zone (?)
IN 5	Weichsellöss, umgelagert, Keldach-Löss
IN 6	Weichsellöss, umgelagert, Keldach-Löss
IN 12	Kaiskorb Nassboden
IN 7	Humuszone OIS 5a, in situ
IN 8	Bleichzone (SwAl), umgelagert
IN 9	Bleichzone (SwAl+Bt), umgelagert
IN 10	Eem-Bt (SdBt), umgelagert
IN 11	Eem-Bt (SdBt2), in situ

Sample	Description
IN 1	Loess loam, MBt, modern soil
IN 2	Brabant-loess, in situ
IN 3	leached loess, Eben zone (?)
IN 4	leached loess, Eben zone (?)
IN 5	Weichselian loess, rewokt, Keldach-Loess
IN 6	Weichselian loess, rewokt, Keldach-Loess
IN 12	Loess, tundra gley paleosoil, Kaiskorb soil (?)
IN 7	Loess loam, A horizon, in situ, OIS 5a
IN 8	Loess loam, reworked, OIS 5
IN 9	Loess loam, reworked (Bt/Eg horizon)
IN 10	Loess loam, dense Btg horizon, reworked, Eemian soil (OIS 5e)
IN 11	Eemian Bt (OIS 5e), in situ

Fig. 5: Geological Stepped Profile Feature Nr. 70; soil samples IN 1–12: M. Kehl; IRSL samples Ind 1–9: Preliminary IRSL ages M. Frechen (drawing by M.Goerke, LVR-ABR).

Abb. 5: Geologisches Stufenprofil Stelle 70, Bodenproben IN 1–12: M. Kehl; IRSL-Proben Ind 1–9: Vorläufige IRSL-Alter M. Frechen (Profilzeichnung M. Goerke, LVR-ABR).

Kooi 1974), which originated from uprooted Eemian spruce trees. These shallow rooting trees have been determined for this period along with pine trees (see U. Tegtmeier in Kels et al. 2009). Pine trees, however, have deep roots and cannot be responsible to create such shallow pits.

The chronology as well as the character of the fallen-tree pits were additionally confirmed by microscopic analysis (see Kehl, Frechen & Thissen, in preparation). The fallen-tree structures appear to be favorable for habitation. The remaining root platform can be used as a construction element by the settlers to build a „fallen-tree shelter". This seems even more probable, since an oval concentration of lithic artefacts with clear boundaries appeared nearby to the central features (Fig. 4, grey area). It seems reasonable, that the people of the camp specifically sought out fallen tree groups near to the Maas terrace to build simple dwellings with little effort.

The excavation campaign WW124 (WW2005/91 and WW2006/74) ended by September 2006 and the excavation area was dug away by the mining operation. The archaeologically investigated area of the Palaeolithic site in Altdorf was about 3000 m².

The lithic assemblage, about 700 unmodified artefacts, retouched tools and cores includes typical Micoquien forms like unifacial knives, Kostenki- and Pradnik-knives, Levallois flakes and cores, and also Upper Palaeolithic elements like burins, scrapers, blades and blade-cores. This inventory can be favourably compared and correlated with the nearby Eemian site Moenchengladbach-Rheindahlen, layer B1 (c. 125 ka BP; Thissen 2006). Their well-preserved state and already macroscopically visible use traces made the Altdorf artefacts very suitable for microwear study.

3 Microscopic use-wear and residue analysis

In this study, all modified artefacts and selected non-retouched pieces from Inden-Altdorf were subjected to high and low power microscopic use-wear analysis (Pawlik & Thissen 2008). By March 2009, 120 artefacts out of presently 136 analysed were identified as used (Table 2). 144 activities were recognised including scraping, cutting, engraving, chiselling and combinations of these tasks. Five tools were used as perforators and 15 projectile implements were identified. A sandstone pebble was used as a grinder, perhaps for smoothing a wooden shaft. The assemblage contains three more grinding stones as well as two potential "querns" made of sandstone.

Table 2: Use-wear analysis: Reconstructed function and assumed contact material (136 analysed artefacts).

Tabelle 2: Gebrauchsspurenanalyse: Rekonstruierte Funktion und angenommenes Kontaktmaterial (136 untersuchte Artefakte).

Activity	Assumed contact material / Function												
	Meat/Skin processing, butchering	Hide/ Leather working	Wood / Bone / Antler	Ivory	Plants	Mineral	Birch tar production	"Hafting and Retooling"*	Multiple materials	Hunting	Undeterm.	No traces	Total
Projectile implement										15**			15
Scraping, Planing		1	17	1	3	1		7			1		31
Cutting	3	10	3		3				1				20
Scraping&Cutting		4	2	1	5				3				15
Other combinations		1							15				16
Drilling, perforating		4									1		5
Gouge, engraving			6			3		1	1				11
Chisel			6					3			2		11
Grinding								1					1
"Pitch catcher"							2						2
Undeterminable		1			2			5			9		17
No use traces												16	16
Total	3	21	34	2	13	4	2	17	20	15	13	16	160

** "Hafting-and-Retooling (after Keeley 1982): Replacing worn and damaged implements; maintenance and reworking of shafts and fittings*

*** 3 projectile implements were also used for cutting activities*

An important role for the reconstruction of Palaeohistoric activities and technologies at Altdorf played the determination of residues. Besides edge damage and micropolish, residues on stone tool surfaces are wear traces whose identification can give clues to their former use. Residues from the worked materials remain sometimes -although not frequently- on the functional parts of the tools. Approaches to the identification of blood or starch were extensively discussed by a number of authors (Loy 1983, 1991; Fullagar 1998; Torrence & Barton 2006).

Residues not only originate from the contact or working material but can be the remains from the tool's hafting and handling. Experimentally created birch pitch and archaeological birch pitch samples from several European Upper Palaeolithic, Mesolithic and Neolithic sites helped to identify these residues in a comparative multi-level analysis

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Fig. 6: The excavation in Altdorf during July 2006. To the right of the profile the colleagues M. Frechen, M. Kehl and M. Goerke, and by the mechanical excavator W. Schürmann.

Abb. 6: Die Ausgrabung in Altdorf im Juli 2006. Rechts am Profil die Kollegen M. Frechen, M. Kehl und M. Goerke, und am Hydraulikbagger W. Schürmann.

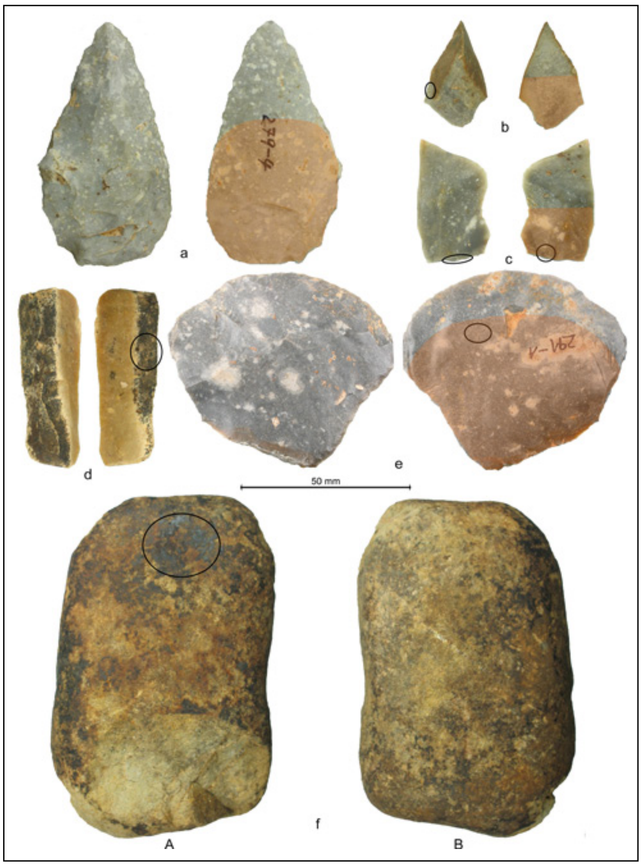

Fig. 7: a) unifacial point no. 279-4, b) triangular pointed flake no. 470-1, c) pointed flake no. 467-1, d) unilaterally hafted blade 455-1, e) scraper no. 291-1, f) sandstone pebble covered with pitch no. 261-3. Presumed hafted areas are shaded; areas where microphotographs were taken are circled.

Abb. 7: a) Unifaziale Spitze Nr. 279-4, b) dreieckiger, spitz zulaufender Abschlag Nr. 470-1, c) spitz zulaufender Abschlag Nr. 467-1, d) unilateral geschäftete Klinge Nr. 455-1, e) Schaber Nr. 291-1, f) mit Birkenpech bedecktes Sandsteingeröll Nr. 261-3. Mutmaßliche Schäftungsbereiche sind schattiert; photographierte Bereiche sind umrandet.

(Pawlik 1995, 1997, 2004; Baales 2002). It combined optical microscopy, SEM and energy-dispersive analysis of X-rays (EDX). The results lead to the identification of these residues as the remains of birch pitch used as hafting mastic (Rottländer 1991). More so, since archaeological evidence -at least for Europe- exists only for adhesives deriving from birch (Weiner 2005: 20).

Birch pitch is produced in a process called dry distillation (Sandermann 1965; Funke 1969; Rottländer 1991). It usually requires the use of air-tight containers known as retorts. The retort is filled with birch bark rolls and set into a charcoal fire. During the heating process, the hot oxygen-free atmosphere inside the retort causes the bark to completely transform into a liquid tar. While this retort distillation is known to have been practiced since the 10th century AD (Weiner 1988) the use of such containers can hardly be considered for prehistoric pitch production. Even for the Neolithic, there is a remarkable absence of retorts or any fragments of retorts in the archaeological record (Weiner 1992).

The comparative analysis of archaeological pitch and experimental replication suggested that prehistoric birch pitch could have been made by turning a narrow pit with stone cover into a "retort" (Pawlik 1995, 2004; Palmer 2007). A cigar-shaped roll of birch bark, similar to findings from the Mesolithic (Kind 1997), is lighted at one end and placed with the burning end ahead into the pit. The smouldering bark takes away the oxygen inside the pit and will cause the bark to "sweat out" pitch drops. A stone placed at the pit's bottom is helpful to catch the pitch. This pitch is a sticky liquid while hot and can be applied immediately.

Such residues were observed on 82 artefacts, on projectile points as well as working tools. They appear as blackish drops and streaks of resin-type material on the basal area, e.g. on a unifacial point (Fig. 7a) or in some cases completely cover the former hafted area like on a laterally hafted blade (no. 455-1;

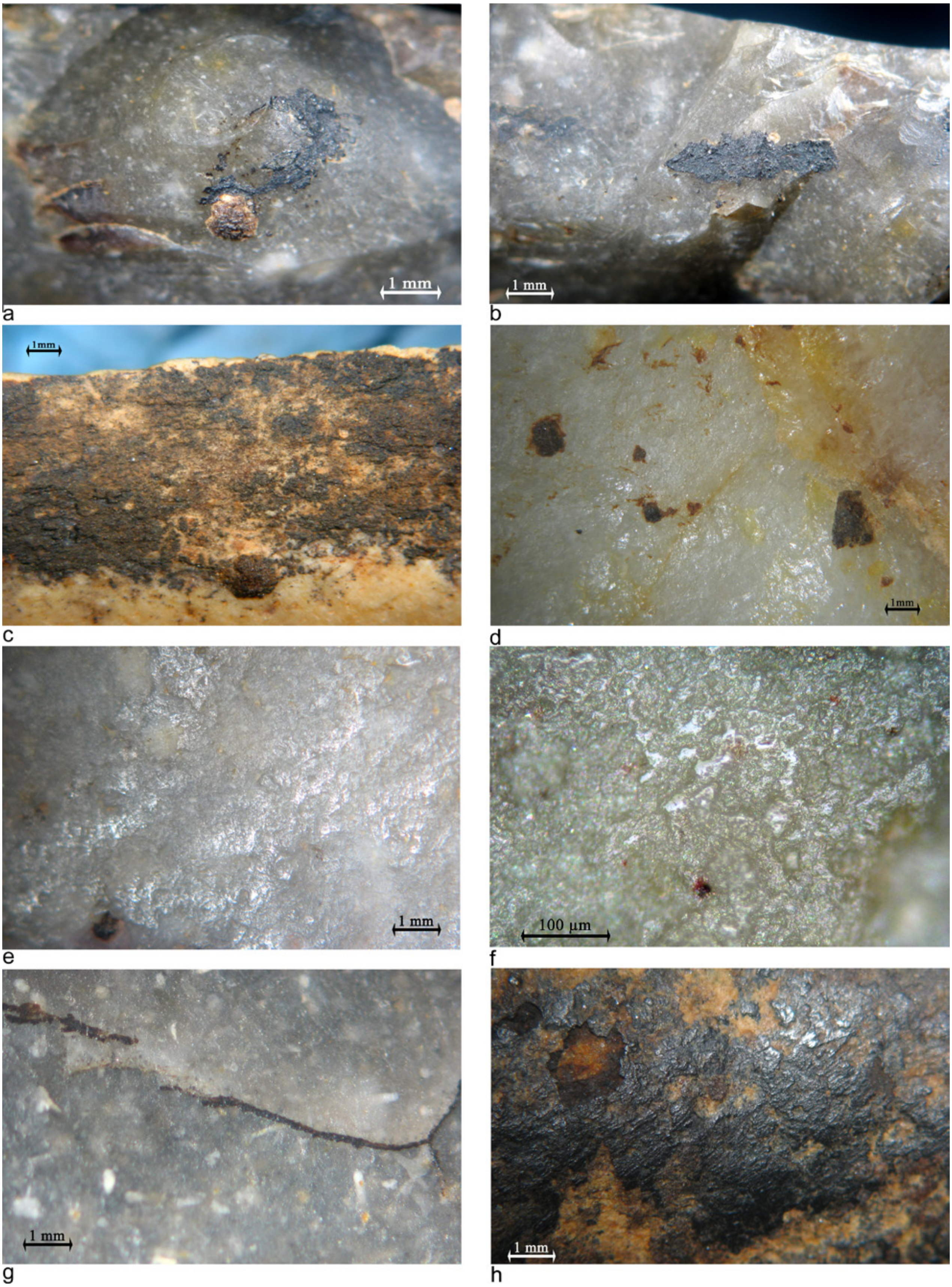

Fig. 8: a) Birch pitch residues on the bulb of no. 467-1, b) residues on the striking platform of no. 467-1, c) Birch pitch covering the lateral edge of no. 455-1, d) pitch residues associated with hafting wear on no. 470-1, e) residues associated with hafting micropolish on a unifacial point no. 279-4, f) residues and hafting micropolish on a Kostenki-knife fragment no 202-1, g) birch pitch filled hairline fissures on the surface of scraper no. 291-1, h) birch pitch cover on a flat sandstone pebble no. 261-3.

Abb. 8: a) Birkenpechresiduen auf dem Bulbus von Nr. 467-1, b) Residuen auf dem Schlagflächenrest von Nr. 467-1, c) mit Birkenpech bedeckte Lateralkante von Nr. 455-1, d) Gemeinsam mit Schäftungsgebrauchspuren auftretende Pechresiduen an Nr. 470-1, e) Residuen und Schäftungspolituren auf der unifaziellen Spitze Nr. 279-4, f) Residuen und Schäftungspolituren auf dem Fragment eines Kostenkimessers Nr. 202-1, g) In Haarrisse eingeflossenes Birkenpech auf der Oberfläche des Schabers Nr. 291-1, h) Mit Birkenpech bedecktes flaches Sandsteingeröll Nr. 261-3.

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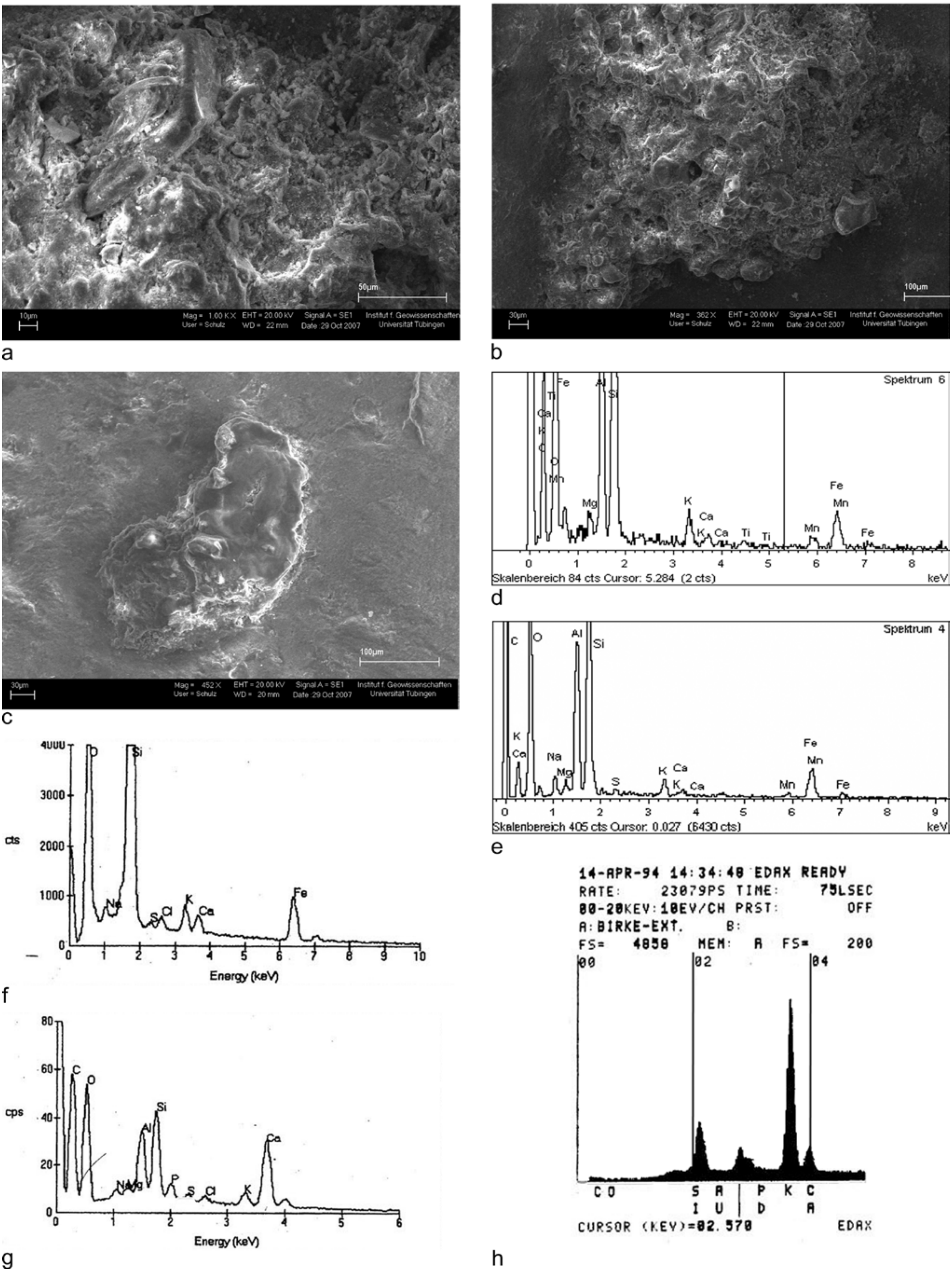

Fig. 9: a, b) SEM image of residues with molten plant tissue frazzles and fibres embedded in an amorphous matrix of solidified pitch on no. 470-1, c) sediment particles in a small clot of solidified pitch on no. 467-1, d and e) EDX analysis of residues from no. 470-1, f) EDX histogram of birch pitch residues from Burgäschisee-Süd, g) EDX histogram of birch pitch residues from Henauhof-Nord II, h) EDX histogram of experimental birch pitch.

Abb. 9: a, b) Rasterelktronmikroskopische Aufnahme der Residuen mit in eine amorphe Matrix aus Pech eingebetteten, angeschmolzenen Pflanzenfasern und -geweberesten auf Nr. 470-1, c) an einem erstarrten Pechklümpchen anhaftende Sedimentpartikel an Nr. 467-1, d , e) EDX-Analyse der Residuen auf Nr. 470-1, f) EDX-Histogramm von Birkenpechresten aus Burgäschisee-Süd, g) EDX-Histogramm von Birkenpechresiduen aus Henauhof-Nord II, h) EDX-Histogramm von experimentell hergestelltem Birkenrindenpech.

Fig. 7d). On artefacts identified as projectile implements, e.g. a pointed and triangular shaped flake (no. 470-1, Fig. 7b), and a blade with transverse termination (no. 467-1, Fig. 7c), residues occur mainly on their proximal parts including the platform remnant. They appear under the stereo-microscope as a dried brownish black viscous liquid (Fig. 8a-c). The residues are often associated with hafting micropolishes (Pawlik 2004) caused by minor movements of the shaft (Fig. 8d–f). The liquid state of the pitch during its application is substantiated by an observation on a scraper (no. 291-1, Fig. 7e): Here, the material filled hairline fissures in the flint surface before it solidified (Fig. 8g). A flat sandstone pebble (261-3, Fig. 7f) is almost completely covered with residues (Fig. 8h) to a maximum thickness of approximately 100 µm suggesting a potential use to catch the hot liquid pitch inside the pit (Palmer 2007).

The residues then underwent closer inspection under a scanning electron microscope LEO 1450-VP, Everhart-Thornley SE-Detector and 4-Quadrant BSE-Detector in connection with an EDX-system OXFORD INCA Energy 200 Premium Si (Li) SATW-Detector. The SEM showed layers of molten plant tissue frazzles and fibres in an amorphous matrix of solidified pitch, thus indicating the origin of the residues (Fig. 9a, b), and embedded sediment particles in the sticky pitch (Fig. 9c). The presence of unaltered primary plant matter within the amorphous matrix was as well a typical feature of experimental pitch and the aforementioned samples from Mesolithic and Neolithic contexts (Pawlik 1995: 209–211).

Following the SEM analysis, Energy-dispersive X-ray analysis was undertaken to detect the elementary composition of the residues. The spectrum of elements acquired from several residue samples shows a significant peak for carbon, verifying the organic nature of the samples (Fig. 9d, e). Various subsequent elements were detected: Potassium (K), Calcium (Ca), Sulphur (S) as well as Iron (Fe), Manganese (Mn), Aluminium (Al), Sodium (Na) and Magnesium (Mg). The latter elements very likely originate from the sediment. More significant is the presence of Ca, K and S. Their traces are shown in considerable quantities as well in the EDX-histograms of Mesolithic and Neolithic birch pitch (Fig. 9f, g). Also experimentally created pitch indicated the presence of Ca and K (Fig. 9h), presumably originating from the exposure to fire and ash during processing and use (Pawlik 1995: 197).

4 Discussion and Conclusion

Modern behavioural patterns and evidence for mastering complex technologies have been recognized at a c.120 ka old site in western Germany. In a multi-level micro-wear analysis, residues on stone tools from Inden-Altdorf have been identified as a pitch produced by the distillation of birch bark. Birch pitch is the oldest known synthetic material and was used in Prehistoric Europe as an adhesive to fix stone tools on wooden shafts (Weiner 2005). This kind of composite or multicomponent tool making requires planning and the execution of complex sequences of action and is regarded as indicator for modern human behaviour (Ambrose 2010). It was until now commonly associated with modern *Homo sapiens* of the last glacial period and the Holocene. The pitch residues found on the Micoquien tools from Inden-Altdorf predate this by far. The use of birch pitch in the Middle Palaeolithic is furthermore supported from another Micoquien site at Königsaue (Mania & Toepfer 1973; Koller et al. 2001; Grünberg 2002). However, only at Altdorf appeared formerly hafted tools in higher numbers and asscociated with settlements structures within a stratigraphical secured context.

This analysis delivered direct evidence that Micoquien lithic technology featured the use of stone tools as hafted implements fixed onto wooden shafts. The hafting traces appeared not only on projectile points but on working tools as well. The resemblance of their visual appearance and elementary spectrum with much younger Neolithic, Mesolithic and Upper Palaeolithic birch pitch is striking. It illustrates that at Inden-Altdorf a very similar, if not the same, material and method of pitch production was already in use during OIS 5e. A natural formation of the residues can be excluded due to their distribution on the tools, the absence of *Betula* charcoal at Altdorf and the production method itself.

Evidence for the production of synthetic pitch and the use of an innovative composite tool technology is still uncommon in the Palaeolithic record. The discovery by Böeda et al. (1996, 2008) of processed natural bitumen on two artefacts from the penultimate Moustérien layer at Umm el Tlel demonstrated the existence of composite technology to at least 40 ka to 70 ka BP. However, their proximity to overlying Transitional and Aurignacien levels at Umm el Tlel leaves open the question of which species of human was producing these pieces. The Königsaue evidence pushes the ability to create hafting mastic back to more than 45 ky to app. 80 ky as well; the Inden-Altdorf evidence pushes it back even further, to the last interglacial. Despite this much greater antiquity, distinguishing the likely fabricator as *Homo neanderthalensis* or *Homo sapiens* seems problematic.

Initial occupation of the Levant by *Homo sapiens* is currently dated to 130–100 ka BP (Grün et al. 2005). It has tended to be portrayed as an aborted settlement, with groups either becoming extinct or being forced to retreat into Africa because of worsening climatic conditions c.75 ka BP. Modern humans do not re-appear in the Levant until c.45 ka BP (Shea 2007) when they then move into the European peninsula. On current evidence, we also consider the second model and that the hominids connected with the Inden-Altdorf site were possibly early *Homo sapiens* (Thissen 2006: 141–171); an interpretation also suggested by Koller et al. (2001) for the Königsaue A find. These data are in support of the possibility that modern humans may have penetrated deeper into the European peninsula than previously thought during their first migration from Africa.

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Author contributions

J.Th. directed the excavations at Altdorf, prepared the excavation report and undertook the morphological analysis of the lithic materials. A.P. undertook the High Power and Low Power use-wear and residue analysis, SEM analysis and EDX analysis.

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