Quartär

Internationales Jahrbuch zur Eiszeitalter- und Steinzeitforschung

International Yearbook for Ice Age and Stone Age Research

Band – *Volume*
63

Edited by

Werner Müller, Sandrine Costamagno, Berit V. Eriksen, Thomas Hauck,
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Verlag Marie Leidorf GmbH · Rahden/Westf.
2016

200 Seiten mit 160 Abbildungen

Manuskript-Richtlinien und weitere Informationen unter http://www.quartaer.eu
Instructions for authors and supplementary information at http://www.quartaer.eu

Bibliographische Information der Deutschen Nationalbibliothek

Müller, Werner / Costamagno, Sandrine / Eriksen, Berit V. / Hauck, Thomas / Mester, Zsolt / Moreau, Luc / Nigst, Philip R. / Pastoors, Andreas / Richter, Daniel / Schmidt, Isabell / Street, Martin / Turner, Elaine (Eds.):
Quartär: Internationales Jahrbuch zur Eiszeitalter- und Steinzeitforschung; Band 63
International Yearbook for Ice Age and Stone Age Research; Volume 63
Rahden/Westf.: Leidorf, 2016
ISBN: 978-3-86757-929-5

Die Deutsche Nationalbibliothek verzeichnet diese Publikation in der Deutschen Nationalbibliographie.
Detaillierte bibliographische Daten sind im Internet über http://dnb.ddb.de abrufbar.

Gedruckt auf alterungsbeständigem Papier

Verlag Marie Leidorf GmbH
Geschäftsführer: Dr. Bert Wiegel
Stellerloh 65 - D-32369 Rahden/Westf.

Tel: +49/(0)5771/ 9510-74
Fax: +49/(0)5771/ 9510-75
E-Mail: info@vml.de
Internet: http://www.vml.de

ISBN 978-3-86757-929-5
ISSN 0375-7471

Umschlagentwurf: Werner Müller, CH-Neuchâtel, unter Mitwirkung der Herausgeber
Redaktion: Werner Müller, CH-Neuchâtel, Sandrine Costamagno, F-Toulouse, Berit Valentin Eriksen, D-Schleswig, Thomas Hauck, D-Köln, Zsolt Mester, H-Budapest, Luc Moreau, D-Neuwied, Philip R. Nigst, GB-Cambridge, Andreas Pastoors, D-Mettmann, Daniel Richter, D-Leipzig, Isabell Schmidt, D-Köln, Martin Street, D-Neuwied und Elaine Turner, D-Neuwied
Satz, Layout und Bildnachbearbeitung: Nicole Bößl, D-Erlangen und Werner Müller, CH-Neuchâtel

Druck und Produktion: druckhaus köthen GmbH & Co. KG, D-Köthen

Inhalt - *Contents*

Short-term occupations at the lakeshore: a technological reassessment of the open–air site Königsaue (Germany)
Kurze Aufenthalte am Seeufer: eine technologische Neubetrachtung der Freilandfundstelle Königsaue (Deutschland)

Andrea Picin....................7-32

The Middle Palaeolithic sequence of Ciemna Cave. Some aspects of the site formation process
Die mittelpaläolithische Abfolge der Ciemna-Höhle. Einige Aspekte der Fundplatzgenese

Paweł Valde-Nowak, Bridget Alex, Elisabetta Boaretto, Bolesław Ginter, Krzysztof Sobczyk, Damian Stefański & Mirosław Zając....................33-46

Quantitative stone tools intra-site point and orientation patterns of a Middle Palaeolithic living floor: A GIS multi-scalar spatial and temporal approach
Quantitative Analyse von Verteilungsmustern von Steinartefakten eines mittelpaläolithischen Begehungshorizonts: Ein GIS multi-skalarer räumlicher und zeitlicher Ansatz

Francesca Romagnoli & Manuel Vaquero....................47-60

Technological analysis of bifacial leafpoints from Middle/Upper Palaeolithic transitional industries
Technologische Untersuchungen an bifaziellen Blattspitzen aus Technokomplexen am Übergang vom Mittel- zum Jungpaläolithikum

Małgorzata Anna Kot....................61-88

Das Gravettien der Hohle Fels-Höhle und seine Bedeutung für die kulturelle Evolution des europäischen Jungpaläolithikums
The Gravettian of Hohle Fels Cave and its implications for the cultural evolution of the European Upper Palaeolithic

Andreas Taller & Nicholas J. Conard....................89-123

Raw material procurement economy and mobility in Late Palaeolithic Northern Bavaria
Rohmaterialbezug und Mobilitätsmuster im Spätpaläolithikum Nordbayerns

Florian Sauer....................125-135

Wesseling – A Federmessergruppen settlement on the banks of the Rhine
Wesseling – Eine Federmessergruppen-Siedlung am Ufer des Rheins

Martin Heinen....................137-155

Handle-cores from northern Jutland and regionality in the Danish Mesolithic – is the assumed east-west split as clear-cut as generally perceived?
Handgriffkernsteine aus Nordjütland und Regionalität im dänischen Mesolithikum – ist die angenommene Teilung zwischen Ost und West so klar begrenzt wie weitläufig angenommen?

Torben Bjarke Ballin...157-168

Mosaic adaptations of Early Holocene hunter-gatherers in central Portugal: lithic and faunal evidence from the open air site of Costa do Pereiro (Torres Novas)
Mosaikförmige Anpassungsstrategien frühholozäner Jäger und Sammler in Zentralportugal: Steinartefakte und Fauna von Costa do Pereiro (Torres Novas)

António Faustino Carvalho, Maria João Valente & João Marreiros...169-187

Book reviews
Buchbesprechungen...**189-200**

The Middle Palaeolithic sequence of Ciemna Cave. Some aspects of the site formation process

Die mittelpaläolithische Abfolge der Ciemna-Höhle. Einige Aspekte der Fundplatzgenese

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Abstract - Ciemna Cave is one of the most important archaeological sites documenting Middle Palaeolithic settlement in Central Europe. It has been excavated since the beginning of the 20th century, providing rich materials commonly known for their bifacial component linked with the Micoquian. Since 2007 a new project has been underway focusing on the Main Chamber, which had so far been unexplored. The outcome is a much more complex picture environmental context and cultural affinities of the site. This article aims to present key questions concerning the record in the Main Chamber, but also to propose a new interpretation of Ciemna Cave as an extensive, diversified cave system. Using 3D modelling of the bedrock of cave system's surrounding area, we propose that dynamic filling of the cave impacted settlement there. It was proved also that the sediments in the Main Chamber are homogenous, which enables radiocarbon dating of the undisturbed sequence layers. Although new radiocarbon determinations were made using state-of-the-art pretreatment methods, we still could not fully resolve the problem of dating the upper part of the section, due to age-limit of this method.

Zusammenfassung - *Die Ciemna-Höhle ist eine der wichtigsten archäologischen Fundstellen des Mittelpaläolithikums in Mitteleuropa. Die seit Beginn des zwanzigsten Jahrhunderts durchgeführten Ausgrabungen haben reiche archäologische Fundmaterialien geliefert. Wegen der bifaziellen Komponente unter den Steinartefakten wurde die Ciemna-Höhle dem Micoquien zugeordnet. Im Jahr 2007 wurde ein neues Projekt ins Leben gerufen, das sich auf die Hauptkammer konzentriert, die bisher unerforscht blieb. Das Ergebnis ist eine viel komplexere ökologische und kulturelle Situation, als bislang bekannt. In dem vorliegenden Beitrag werden die wichtigsten Aspekte der neuen Untersuchungen in der Hauptkammer vorgestellt und eine neue Sichtweise der Fundstelle als komplexes Höhlensystem diskutiert. Eine 3D-Modellierung des anstehenden Untergrunds in der unmittelbaren Umgebung der Höhle zeigt, inwieweit dynamische Prozesse der Sedimentation die Nutzung der Höhle durch den Menschen beeinflusst haben. Dank der Homogenität der Sedimente in der Hauptkammer konnte mittels der Radiokarbon-Methode die ungestörte Sequenz der Schichtenfolge datiert werden. Obwohl neue Radiokarbon Datierungen mit aktuellen Verfahren der Vorbehandlung durchgeführt wurden, konnte das Alter des oberen Teils des Abfolge, aufgrund methodischer Einschränkungen durch das Erreichen der maximalen Messbarkeit, noch nicht bestimmt werden.*

Keywords - Ciemna Cave, Middle Palaeolithic, Micoquian, Taubachian
Ciemna-Höhle, Mittelpaläolithikum, Micoquien, Taubachien

Introduction

Ciemna Cave is located in southern Poland on the Kraków-Częstochowa Upland in the Prądnik Valley (Fig. 1). According to the present cave inventory (Gradziński et al. 2007), the term Ciemna Cave is equated exclusively with the Main Chamber (sector CK – Fig. 2a, b), Tunel and roofless part at the entrance to the Main Chamber (sector C – Fig. 3: a), but traditionally, together with Ogrójec (sector CO) and Oborzysko Wielkie (both Fig. 3: b), it relates to the extensive cave system, partly damaged by erosion of the Prądnik valley hillside (Fig. 4). Under that broad definition, Ciemna Cave has been of interest to archaeologists since the second half of the 19th century. Since that time it has been explored by archaeologists multiple times. Stanisław J. Czarnowski (1924) was the first archaeologist who made significant explorations in Ogrójec and Oborzysko Wielkie at the beginning of the 20th century. In 1912, in cooperation with Leon Kozłowski and Rudolf R. Schmidt from Tübingen

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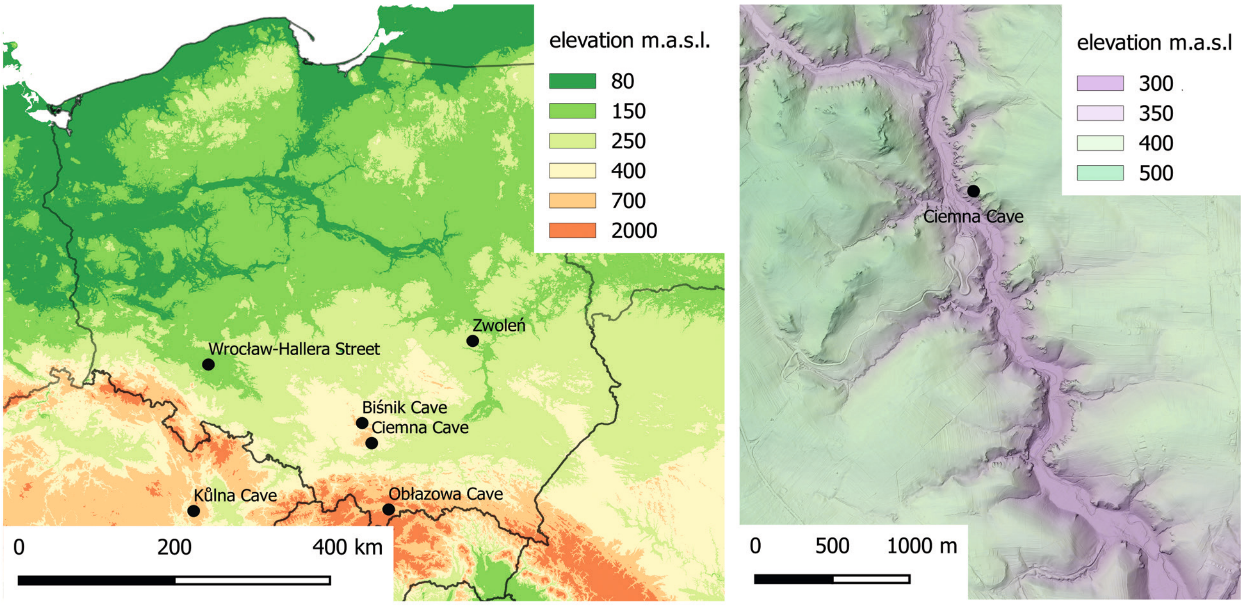

Fig. 1. Location of Ciemna Cave in Poland and in Prądnik valley.
Abb. 1. *Die Lage von Ciemna-Höhle in Polen und im Prądnik-Tal.*

University, he made his initial survey at the threshold of Oborzysko Wielkie, but did not reach the Palaeolithic layer. Excavations carried out by Stefan Krukowski in 1918-19 and Stanisław Kowalski in 1963-68 provided a number of sections documenting complex stratigraphy as well as stratified assemblages. Bifacial materials from Ogrójec were of great importance to Krukowski in terms of defining the Ojców industry as well as the regional Micoquian ("Prądnicki cykl" – Krukowski 1924, 1939-1948). Those materials were also later differentiated by Kowalski from other Middle Palaeolithic (MP) assemblages (Kowalski 1967). These assemblages were repeatedly included in synthetic Micoquian descriptions (Bosinski 1967; Chmielewski 1975; Kozłowski & Kozłowski 1977; Jöris 1992, 2006; Richter 1997, 2002).

Because no conclusive or comprehensive studies of this complex archaeological site have been published, a new interdisciplinary excavation project was launched in 2007. The current excavations are located in the previously unexplored Main Chamber (sector CK). Since the first two trenches have finished, a rich MP stratigraphy embedded in a complex environmental record has been reported. It comprises 24 lithological rubble-clay like layers, which constitute 6 main geological series. The geological section is approximately 12 meters wide with a depth of 6 meters to bedrock (Fig. 2). This new finding caused an essential shift in understanding of the site, which had been previously known for its place in the Micoquian debate (Prądnikian, Prondnikian) to a multi-layered MP site with a rich environmental and cultural record. The new outcome offers high potential for productive future research on Neanderthal settlement in the Kraków-Częstochowa upland. However, unequivocal data from radiocarbon dating and chemical investigation of geological layers poses questions concerning the evaluation of that record. One of the essential issues is an explanation of the dynamic geological conditions across the cave system. Further investigation of the site formation processes seems to be crucial for understanding that variation. It is also important for assessing the impact of geologic processes on MP settlement at the site. Another issue is the homogeneity of the complex stratigraphy observed in the Main Chamber. This unique evidence calls for detailed examination to confirm its usefulness in framing Late Pleistocene environmental and cultural record. As the new agenda of the Ciemna project is to examine the youngest Neanderthal settlement, another the substantial issue is to establish a precise absolute chronology of the Micoquian sequence, which according to the so far published results remains ambiguous.

Methods

Cave sites often contain extraordinary environmental and cultural records, but require complex procedures in the course of excavation. Keeping this in mind, since the beginning of the new project precise procedures have been followed. At Ciemna Cave, a coordinate system follows the axis of the Main Chamber to obtain longitudinal and perpendicular sections with elevation measured in meters above sea level. The excavations were carried out in adjoining trenches covering altogether over 42 m^2. Lithics and bones were collected during excavation with precise coordinates using a total station. The sediments were excavated in arbitrary units of 10 cm in a 1 × 1 m grid. All sediments were wet-sieved through a 1 mm mesh. To obtain plant and animal macrofossils, samples were taken

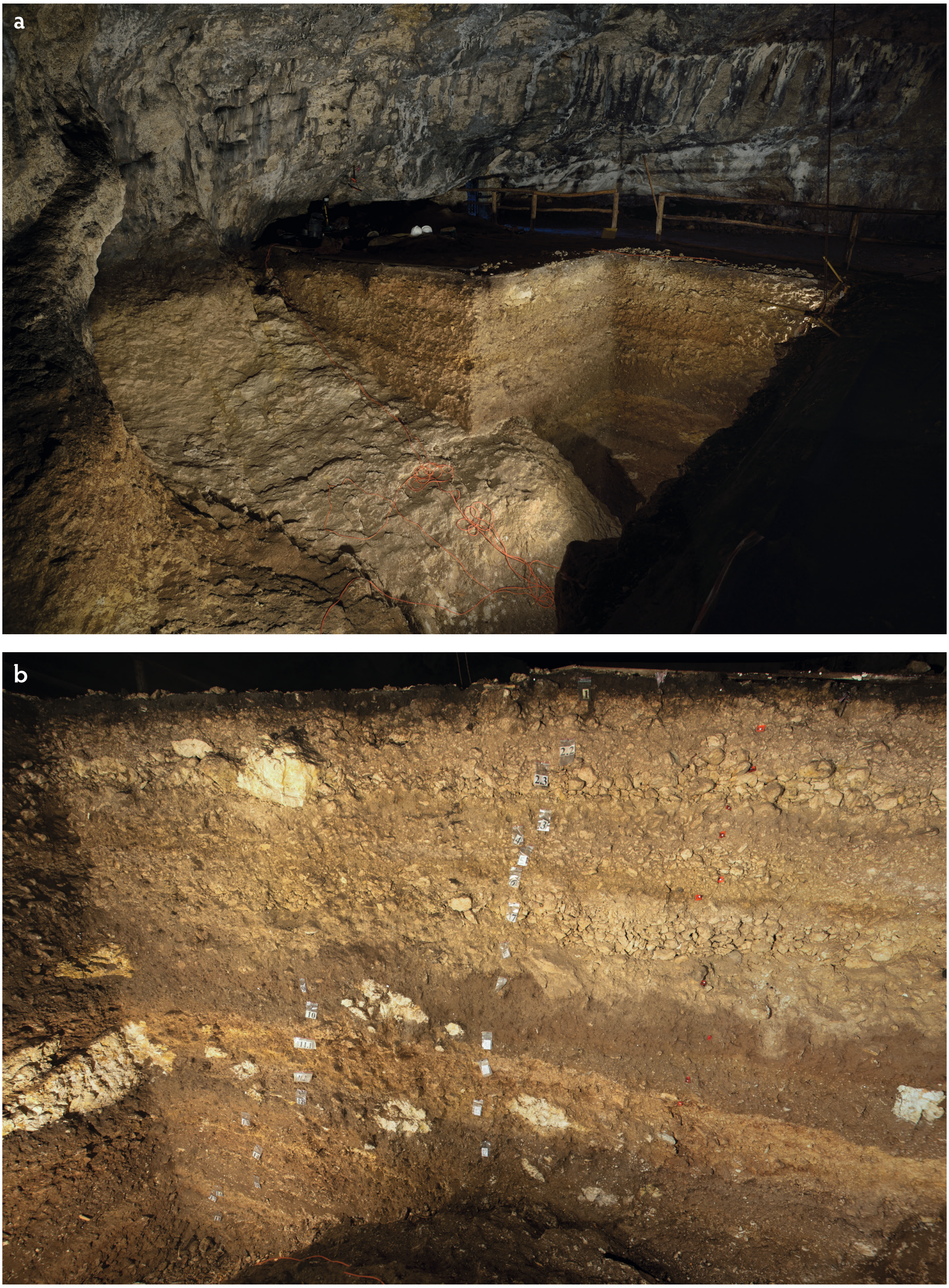

Fig. 2. Photos of the Main Chamber (sector CK) of the Ciemna Cave system. a: W and N sections of trench I and III (Photo: R. Cieślik); b: the northern part of E section of trenches I and II (Photo: D. Stefański).

Abb. 2. *Fotos der Hauptkammer (Sektor CK) des Ciemna-Höhlensystems. a: W und N Querschnitte von Schnitt I und III (Photo: R. Cieślik); b: Nordteil von E Querschnitt von Schnitt I und II (Foto: D. Stefański).*

Fig. 3. Photos of particular parts of the Ciemna Cave system. a: the roofless part at the gate to the Main Chamber (sector C) and Tunel (Photo: D. Stefański); b: Ogrójec (sector CO) and Oborzysko Wielkie (Photo: D. Stefański).

Abb. 3. *Fotos einzelner Bereiche des Ciemna-Höhlensystems. a: Dachloser Teil beim Eingang zum Hauptkammer (Sektor C) und Tunnel (Foto: D. Stefański); b: Ogrójec (Sektor CO) und Oborzysko Wielkie (Foto: D. Stefański).*

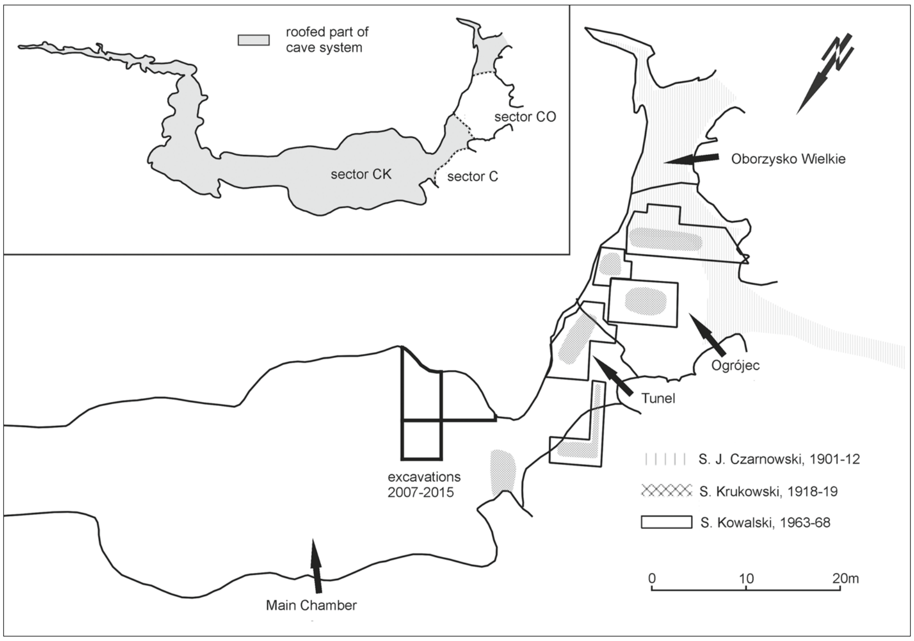

Fig. 4. Plan of the Ciemna Cave system.
Abb. 4. *Grundplan des Ciemna-Höhlensystems.*

from each excavation unit and processed by means of flotation and wet-sieving with a 0.5 mm mesh. Geological samples were taken directly from section walls. Each section was documented using photogrammetry. All data, consisting of georefe-renced photogrammetry measurements (artefacts, bones, geological samples etc.), and post-excavation analyses are managed in an MS-Access database and QGIS software. The research has been conducted by a broad interdisciplinary team since the beginning of the project. So far only full geological determinations of the section (Valde-Nowak et al. 2014) and radiocarbon dating results (Alex et al. 2017) have been published. As the project is ongoing, zoological, anthracological, and other studies have only been preliminarily reported.

Investigation of the site formation processes is intended to explain a variety of geologic and stratigraphic conditions recorded in particular parts of the cave system. Although this task requires complex multiproxy data, a first step, which is an attempt to model the shape of bedrock has been produced. It was done on the basis of the available digital terrain model provided by Informatyczny System Osłony Kraju (ISOK), ground-penetrating radar soundings (GPR), and published plans (Gradziński et al. 2007). Subsequently, this process was executed using sections documented in the course of archaeological exploration (Krukowski 1939-1948; Kowalski 2006). The ISOK data were obtained through airborne laser scanning (ALS). The acquired point cloud underwent a process of classification to generate products like a digital terrain model (class: land and water) and a numerical model of coverage area (class: land, buildings, vegetation, water) it can be applied only to the open parts of the cave system. The GRP method has allowed for study of the cave bottom outside the excavated area and has brought valuable data to the understanding of the process of cave filling. The geophysical soundings were conducted twice. The first investigation was carried out before the excavations (Szynkiewicz 2007) and subsequently, in the course of excavations, when unearthed parts of the Main Chamber allowed for calibration of the measurements (Karczewski & Ostrowski 2013). The last mentioned survey was carried out by means of radar equipped with a 250 GHz antenna. During that investigation 19 sections were obtained, but the most interesting is a long section along the Main Chamber axis which shows a surprising depth of the filling visualised by 3D processing in Petrel software (Fig. 5).

Sediment preservation is a key question when analysing the stratigraphic sequence of environmental and human record. To answer this question, an analysis based on the 3D coordinated data acquired during the exploration process was performed. This examination was applied to bones, which were numerous enough to produce a reliable result. The aim was to check for levelling of the bones, which would confirm a stable deposition process, or to identify a distribution, which could imply mixing of the sediment. The outcome of that analysis is crucial to further steps, first of all to date the section. The analysis was performed by plotting bones from trenches I and II on the E section (the maximum X distance was 4 m), and analyzing the distribution by means of density function. In this case the same coordination was applied to partition the plot by Voronoi tessellation to identify the area with the biggest density of bones. Additional data comes from a spatial arrangement of

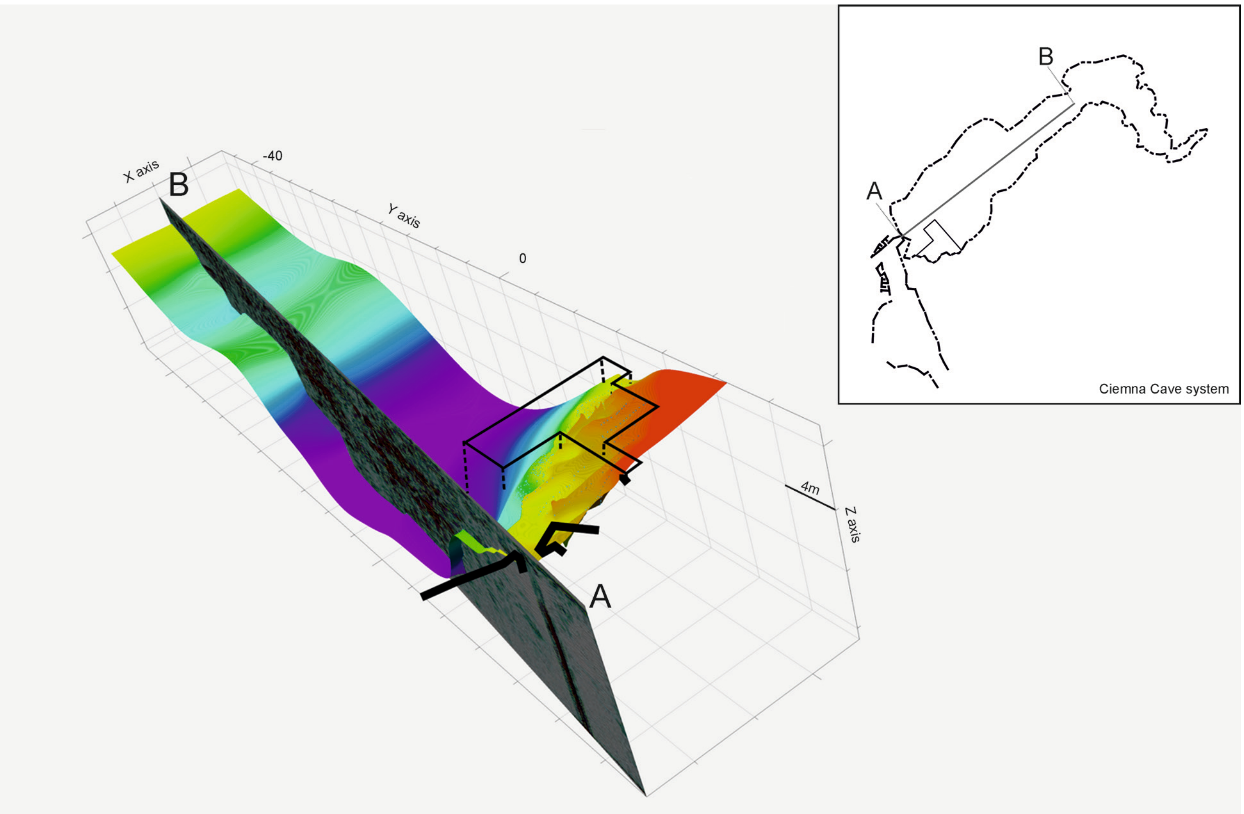

Fig. 5. Visualisation of GPR soundings along the longest axis of the Main Chamber with archaeological trenches (courtesy of Tomasz Ostrowski).

Abb. 5. *Visualisierung der GPR Sondierung entlang der Längsachse der Hauptkammer mit archäologischen Schnitten (freundliche Mitteilung von Tomasz Ostrowski).*

lithics, which could show a horizontal movement of material.

The chronology of the Micoquian sequence is the most challenging issue. Geological determination by granulometric analysis and rubble smoothing quotients as well as preliminary radiocarbon dates link at least two younger Micoquian levels (III, IV) with the Interpleniglacial (Valde-Nowak et al. 2014). This suggests that the upper portion of the sequence in the Main Chamber may have been deposited close to ~50'000 years ago, the limits of the radiocarbon method. However, producing radiocarbon dates of this age is methodologically challenging because a small amount of modern contamination can alter the date by thousands of years (Bronk Ramsey 2008). Nearly 20 radiocarbon dates have been produced from charcoal, bones, and teeth by different laboratories, using different sampling and pretreatment procedures (Fig. 6). Overall the dates are inconsistent with the samples' stratigraphic positions and do not show increasing age with depth. Therefore a dating program was designed and executed by the D-REAMS Radiocarbon Dating Laboratory, Weizmann Institute of Science, Israel, which focused on dating a sequence of complete long bones from large and medium mammals. Furthermore, these samples were monitored throughout the pretreatment process by Fourier Transform Infrared Spectrometry (FTIR) to ensure that the dated material was well-preserved collagen, and not contaminant material. Four bones met the selection criteria for context and preservation, and were then prepared and dated by accelerator mass spectrometry (AMS) by standard procedures for bone collagen at the D-REAMS Radiocarbon Dating Laboratory. The dating program and results have been reported (Alex et al. 2017).

Results

The current excavation revealed that the geological and archaeological record of sector CK of the Ciemna Cave system is much more complex than previously documented in sector CO (Valde-Nowak et al. 2014, 2016). Although, no detailed comparison was made, sector CK seems similar to the rich but enigmatic sequence documented by Krukowski in sector C. The full geological sequence consists of 24 main layers grouped into 6 series. From an archaeological point of view, the most interesting portion is the rich cultural sequence (levels) of MP industries revealed in series I to IV (Figs. 7 & 8). In addition to three bifacial levels linked with the Micoquian (compared with the only two known from Ogrójec), four other cultural levels were documented. However, it should be mentioned that the density of artefacts in sector CK is significantly lower compared to the rich findings from sector CO.

sector/ layer	date	±	lab code	material	comments	taxa	element	pre-treatement	% eff	% C
CK/2.11	39'600		RTD-7494	bone		large mammal	LBSF*	ultrafiltration	*2.7*	*37.5*
CK/2	42'000	1'000	Poz-23663	bone		*U. spelaeus*	tooth			
CK/2	46'000		Poz-61097	bone	2.8% N, 9.7% C, coll					
CK/3	45'000	2'000	Poz-61103	bone	2.8% N, 9.6% C, coll 1.8%					
CK/3	46'000	3'000	Poz-61096	bone	2.1% N, 7.6% C, coll					
CO/11 acc. Kowalski	37'800	700	Poz-25261	bone		*U. spelaeus*	tooth			
CO/11 acc. Kowalski	41'500	1'000	Poz-27268	burnt bone						
CK/4	40'479	334	RTD-7354	charcoal		*Picea* sp./*Larix* sp.		BA	*35.9*	*51*
CK/4	47'000	3'000	Poz-61100	bone	3.1% N, 10.1% C, coll					
CK/4	55'264	5'017	RTD-7386	bone		*U. spelaeus*	humerus	ultrafiltration	*0.6*	*43.2*
CK/5	39'100	1'000	Poz-61105	bone	2% N, 7% C, coll 1.5%					
CK/5	35'100	700	Poz-61106	bone	1.2% N, 5.2% C, coll 0.8%					
CK/6	38'600	290	OS-84006	bone		*U. spelaeus*				
CK/6	41'500	800	Poz-61091	bone	2.3% N, 8.2% C, coll 1%					
CK/6	45'000		Poz-61099	bone	3.4% N, 10.4% C, coll					
CK/7	34'600	600	Poz-61104	bone	2.1% N, 7.2% C, coll 1.2%					
CK/7	35'300	230	OS-84009	bone		*U. spelaeus*				
CK/8	42'633	397	RTD-7353	charcoal		*Pinus sylvestris*		ABA	*47.9*	*60*
CK/8	46'311	1'358	RTD-7387	bone		*U. spelaeus*	femur	ultrafiltration	*0.7*	*44.2*
CK/8	56'622	6'384	RTD-7388	bone		*U. spelaeus*	tibia	ultrafiltration		

Fig. 6. Radiocarbon dates of bone and charcoal samples from Main Chamber (CK) and Ogrójec (CO) of Ciemna Cave. Bones with laboratory code RTD were dated in the most recent analysis and considered the most reliable; * long bone shaft fragment.

Abb. 6. *Radiokarbondaten von Knochen und Holzkohlen aus der Hauptkammer (CK) und Ogrójec (CO) der Ciemna-Höhle. Knochen mit dem Labornummerncode RTD sind die aktuellsten Messungen und werden somit als die verlässlichsten angesehen; * Langknochen-Schaftfragment.*

Additionally, due to an unexpected rock wall, which limited the surface of the trench, the flint artefacts were not numerous, especially in the lower part of the section.

Series I (layers 19-17) consists of reddish and yellowish clays and silty loams. It is the oldest stratigraphic unit – dated to MIS 6 – recognized during the latest project. The cultural remains are scarce. Only in layer 17 a weak MP (level IX) was documented, which yielded a scraper formed on a flake from bifacial processing.

Series II (layers 16-9) consists of loams and silty loams with abundant limestone rubble. It is brown or greyish brown coloured. Layers 16, 17, and 11.2 exhibit the highest stage of limestone rubble smoothing in the sequence, which suggests an interglacial (or warm Interstadial) age for these layers. Most probably it represents MIS 5. Three MP levels were documented (VIII, VII, VI – Fig. 7). Level VIII (layer 15) is characterized by a relatively high frequency of cores and flakes. It appears to reflect local flint processing with respect to one-platform flake cores, as well as discoid ones. The Levallois technique and small abrupt retouched forms occurred rarely. This inventory has been classified as Mousterian. Level VII (layer 12) is characterized by a high frequency of tools. Levallois technique is clearly present. The level has also been classified as Mousterian. Level VI (layer 10, 9) features a very high frequency of small abruptly retouched tools (pseudotools?). Non-local raw materials such as chocolate flint from the northern boundary of the Holy Cross Mountains and Świeciechów flint from the right bank of the Vistula River occur in trace quantities. This level has been identified as Taubachian.

Series III (layers 8-6) contains limestone debris in a brown and greyish brown sandy silt matrix. The limestone rubble is angular and strongly mechanically weathered, suggesting that the sediments were deposited in the cold Pleniglacial period (MIS 4). This series yields two MP levels (V, IV – Fig. 7 & 8). Level V (layer 8) is also characterized by high frequency of tools. It includes four artefacts of non-local raw materials (two of chocolate flint, two of Carpathian radiolarite). There is no Levallois technique. Bifacial retouched forms are relatively frequent. The paraburin technique and small dimensional abrupt retouched tools are present as well. This level has been classified as Micoquian. The most interesting finding is a tiny, strongly reduced radiolarite handaxe, which may be understood as a "long biography" tool that witnessed long distance penetrations of the Carpathian zone. There are no traces of processing of non-local raw materials at Ciemna Cave, indicating that special attention was paid to valuable artefacts more than a complex pattern of raw material acquisition. It is worth noting that this level documents the first occupational phase of the Micoquian group in the Ciemna Cave. Level IV (layer 6) is very scarce. There is only one artefact made of non-local raw material (Carpathian limnosilicite). Levallois technique is significant. Bifacial retouching and paraburin technique (transversal and diagonal) are documented. This inventory bears a Micoquian character, although the sample is too small for proper classification.

Series IV (layers 5-2.2) consists of brown and greyish brown loams, silty loams, and loess with limestone rubble. Limestone rubble is weathered and smoothed, suggesting a mild climate during deposition of these layers (MIS 3?). Level III (layer 3-2.3) exhibits an extraordinarily high percentage of flakes,

Fig. 7. Ciemna Cave, sector CK – lithics from level V to VIII.
Abb. 7. *Ciemna-Höhle, Sektor CK – Steinartefakte aus den Schichten V bis VIII.*

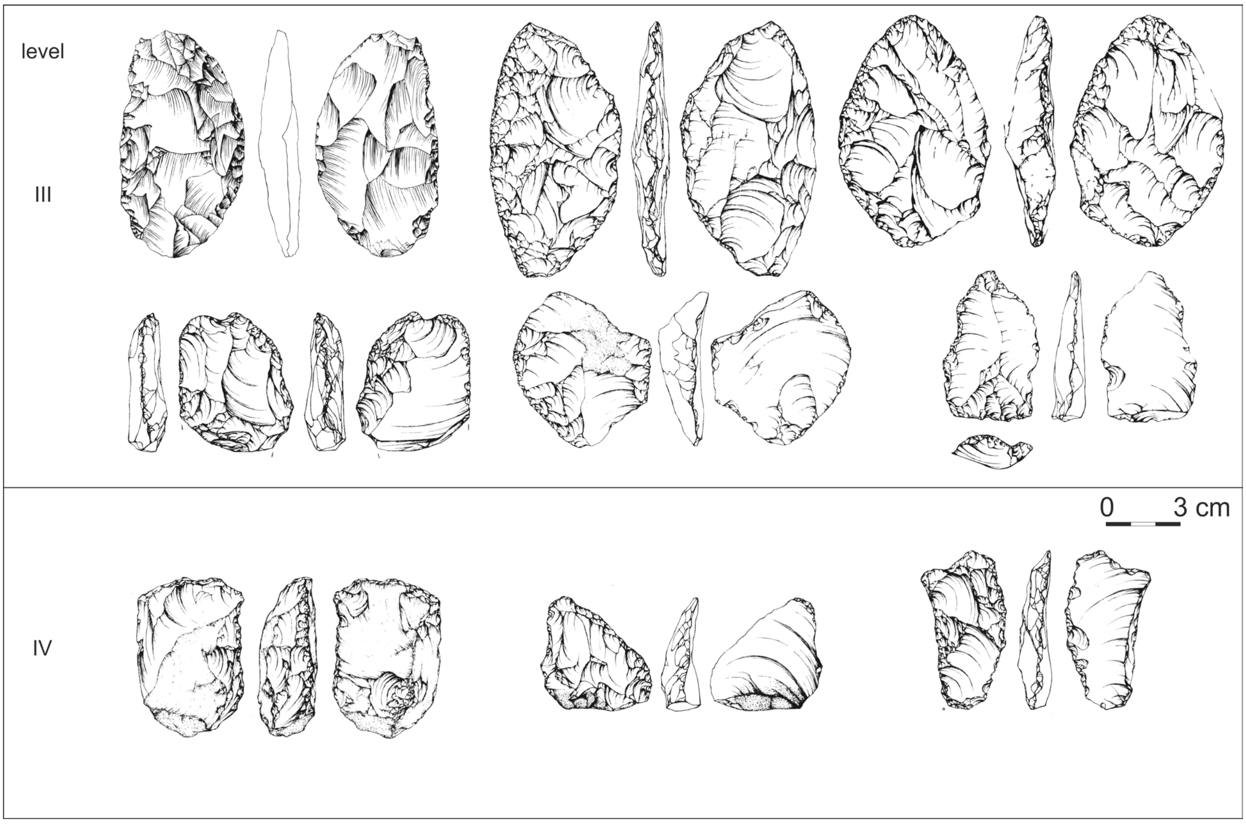

Fig. 8. Ciemna Cave, sector CK – lithics from level III and IV.
Abb. 8. *Ciemna-Höhle, Sektor CK – Steinartefakte aus den Schichten III und IV.*

suggesting local flint processing. Levallois technique and numerous traces of bifacial retouching (in the form of finished tools as well as the many flakes from preparation and repairing) characterize this inventory. The paraburin technique is abundant. The level is classified as Micoquian (Fig. 8).

The summarized result of the rocky bottom modelling of the Ciemna Cave system are shown in the two figures. The first graphic (Fig. 9: a) shows the general relief of the neighbourhood of the cave system. The map precisely indicates the present state of the cave system which has been changed by erosion of Prądnik Valley slopes. The graphic also shows potential primary entrances to the cave assumed to be located at the junction of the cave system with a couloir cut in the limestone rock body. The second graphic (Fig. 9: b) shows the modelling of the rocky bottom of the cave system against the degree of inclination of the rocks and ground out the cave system. The outputs of the modelling can be divided into three categories. The first category shows the most reliable results performed on data coming from archaeological excavations where the bedrock was documented by direct measurement (sector CK) or by a net of sections (sector CO). The second category includes an attempt to generalize the GPR soundings to extend a picture of the Main Chamber. The last category is a fully hypothetical reconstruction (e. g. Tunel). However, it is based on features like a limestone joint system, assumed primary entrances, or even a field observation of a chamber extending over the existing plans. The cave system developed along an almost perpendicular axis, which joins presumably in sector C. It had at least three primary openings towards Prądnik valley. A feature in common throughout the cave system is the strong narrowing of its bottom part. This feature is the most visible in sector CO where a narrow gully approximately 1 meter deep and wide can be observed. This analysis also shows, however, an essential difference between the northern and southern parts of the system (Fig. 10). The first mentioned is much wider. Additionally, it is situated perpendicularly to the valley, presumably joining it with larger openings, which should have provided more light, making the area, especially sector C, more suitable for settlement. The thick layer of cave loams supports that it opened relatively late. Sector CO was much more narrow, longitudinal to the valley with a small entrance open. Before it opened, presumably during the Pleniglacial, it was a secluded place not suitable for settlement. Additionally, the altitude of bedrock shows that it was approximately 2 m lower than the sectors C and CK, making a strong inclination of the ground between those two parts. The collapse of the roof, and of part of the walls flanking the valley, gradually increased the attraction of settlement here.

The outcome of the analysis performed to examine the homogeneity of the sediment is shown in figure (Fig. 11). Although, the picture is partly affected by breaks at the trench border and also by the limitation of the maximum extent of the plotted area (X axis) the picture seems to be coherent. It proves beyond any doubt a clear levelling of the bones in the perpendicular cut of the Main Chamber from its axis to the rocky wall. This interesting pattern shows rather undisturbed filling in this part of the cave system. It certainly reflects also a different environmental condition during deposition. However the detailed taphonomic aspects of this patterning will be tested in future. This result has been additionally corroborated by a tight spatial clustering of the three refits from the younger Micoquian level (Fig. 12).

The most recent radiocarbon dating program focused on dating complete long bones with well-preserved collagen (Alex et al. 2017). Four samples were dated from levels 3-III, 6-IV, and 8-V. Two bone samples produced finite radiocarbon measurements that extend beyond the 50'000 limit of the calibration curve: (RTD-7386) 55'300 ± 5'000 ^{14}C BP, (RTD-7387) 46'300 ± 1'400 ^{14}C BP). The other two samples produced measurements that could not be distinguished from the background, and therefore were given minimum ages: (RTD-7494) >56'000 ^{14}C BP, (RTD-7388) >50'600 ^{14}C BP). Although these dates cannot be reliably calibrated into calendar ages. They indicate that materials in geological layers 3-8 are older than ~50 ka BP.

Discussion

According to the results acquired in the modelling of the cave system it can be argued that differences in cave fillings (which are documented by the series of sections) could have resulted from the morphology of the bedrock. Summarizing the conclusions of modelling, two partly independent units emerge – the sector CO area (probably covering also Oborzysko Wielkie) and the sectors C and CK. The only hypothetical modelling of Tunel, which joins those units together, does not give a strong argument to describe the relation between them. The most logical hypothesis is that both areas were partly separated in the lower part of their sections. In this view, the Main Chamber sequence should match the one described by Krukowski in sector C, which will not be able to be proven until the end of the ongoing project. That separation is the most probable explanation of the relative height difference of the Micoquian levels between CK and CO (ca. 4 metres). It can also explain the surprising differences in the cultural stratigraphy in both areas. The sector CO indicates only two Micoquian levels above a few ambiguous finds, documenting an older settlement below, as opposed to the several cultural levels present in sectors C and CK. This can be explained by the "pendulum effect" which relies on gradual slow filing of the narrow gully in the sector CO area, which extends the available

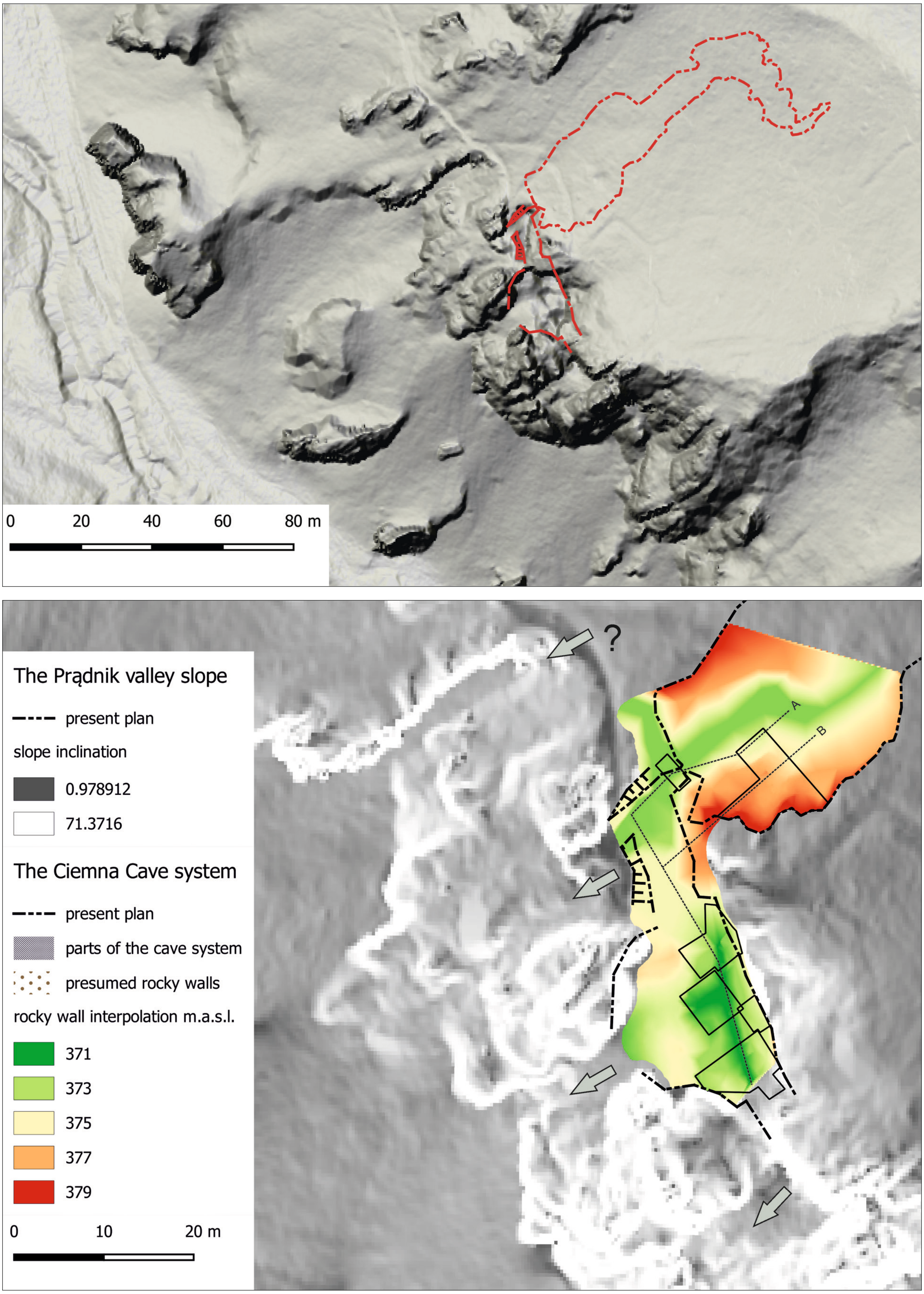

Fig. 9. The Ciemna Cave system. a: map of the sloping of the neighbourhood; b: modelling of the bedrock.

Abb. 9. *Das Ciemna-Höhlensystem. a: Kartierung von Hängen in der Umgebung; b: Modellierung des anstehenden Gesteins.*

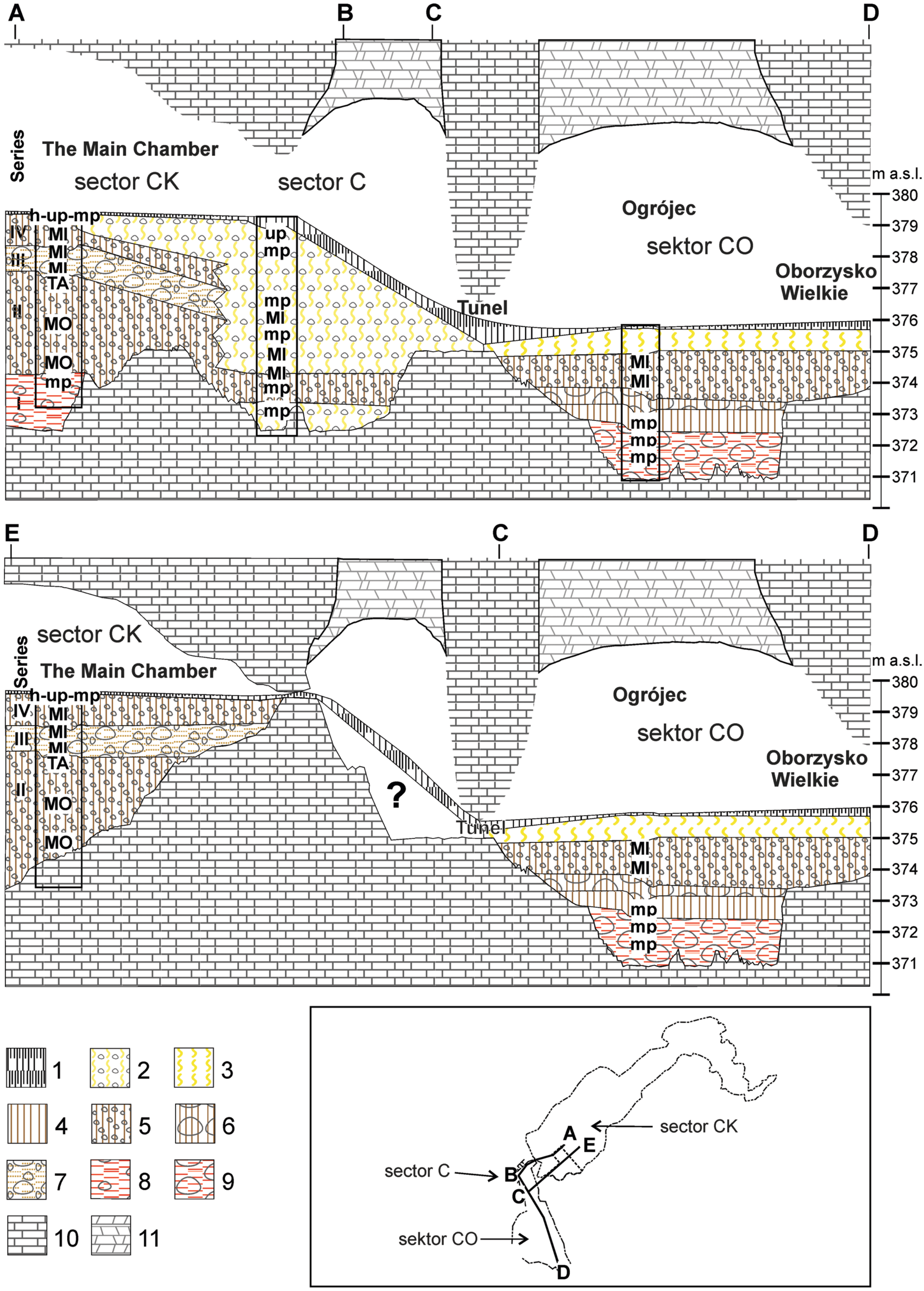

Fig. 10. Synthesized sections of the Ciemna Cave system. 1: humus; 2: loess with limestone rubble; 3: loess; 4: loams; 5: loams and silty loams with limestone rubble; 6: loams and silty loams with limestone debris; 7: limestone debris with sandy-silt matrix; 8: clays and silty loams with limestone rubble; 9: clays and silty loams with limestone debris; 10: limestone; 11: collapsed roof (MIS 4); h-up-mp: Holocene, Upper Palaeolithic, and Middle Palaeolithic; up: Upper Palaeolithic; mp: Middle Palaeolithic; MI: Micoquian; TA: Taubachian; MO: Mousterian.

Abb. 10. *Synthetisierte Querschnitte des Ciemna-Höhlensystems. 1: Humus; 2: Loess mit Kalkschutt; 3: Loess; 4: Lehm; 5: Lehm und schluffiger Lehm mit Kalkschutt; 6: Lehm und schluffiger Lehm mit Kalksand; 7: Kalksand mit sandige Schluffmatrix; 8: Ton und schluffiger Lehm mit Kalkschutt; 9: Ton und schluffiger Lehm mit Kalksand; 10: Kalkstein; 11: eingestürzte Decke (MIS 4); h-up-mp: Holozäne, Jungpaläolithikum und Mittelpaläolithikum; up: Jungpaläolithikum; mp: Mittelpaläolithikum; MI: Micoquien; TA: Taubachien; MO: Moustérien.*

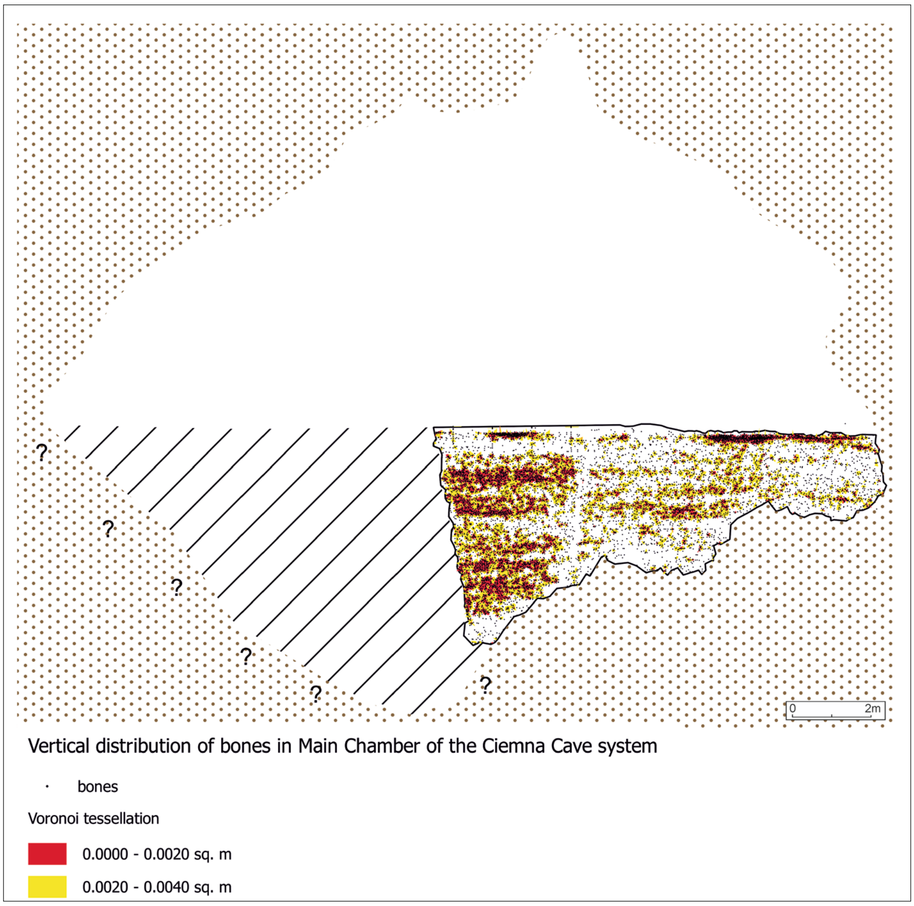

Fig. 11. Ciemna Cave, sector CK – plot of bones and results of Voronoi partitioning.
Abb. 11. *Ciemna-Höhle, Sektor CK – Zusammensetzung von Knochenfunden sowie Voronoi Partionierung.*

settlement surface. The process was combined with opening of this part by destruction of the Prądnik valley slopes. On the other hand, the sectors C and CK offered ideal settlement conditions, but were constantly filling, which eventually restricted easy movement across the cave system. The assumed functional differentiation between particular areas of the cave system may be examined through palaeontological studies. The very small quantity of herbivore remains in the whole sequence of the Pleistocene sediments in the Main Chamber show that Neanderthals did not transport killed animals to the deeper parts of the cave. It is assumed that most of their activity was localized outside the Main Chamber. It is confirmed for the Micoquian episode when a large number of burned bones used as fuel in hearths and large numbers of stone artefacts were collected in sector CO (Wojtal 2007). It is possible that at least since the beginning of the last glaciation the Main Chamber was only used occasionally. The presence of many gnawed and digested carnivore bones shows that the cave was also used by cave bears as hibernation dens. The above mentioned features, together with the low density of artefacts, indicate that Neanderthals used the cave only temporarily, probably when it was not occupied by carnivores.

As bone sample position seems not to have been disturbed stratigraphically, the possibility of postdepositional moving of material does not seem to have affected the radiocarbon chronology. A more relevant constraint is that the samples approach or exceed the age limits of radiocarbon dating. For this reason, the absolute chronology of the sequence of the Micoquian occupations of Ciemna Cave cannot be resolved precisely by this method. However, several important conclusions can be drawn from this examination. For example, levels III, IV, and V were likely deposited prior to 50 ka BP, based on long-bones from these levels dated in the most recent analysis, which produced minimum ages or finite dates beyond the calibration curve. Previously produced radiocarbon dates may not be reliable estimates as not all of these samples were prepared with state-of-the-art methods designed to detect and eliminate contamination.

Allocating the Micoquian levels in Ciemna to over 50 ka BP challenges the very late dating of the Micoquian episodes in signalised in previous papers. If older than 50 ka, the Ciemna Micoquian is chronologically comparable with the outcomes of OSL, TL, and U-Th datings of Micoquian assemblages from Zwoleń – lower & middle level (Schild 2005), Biśnik

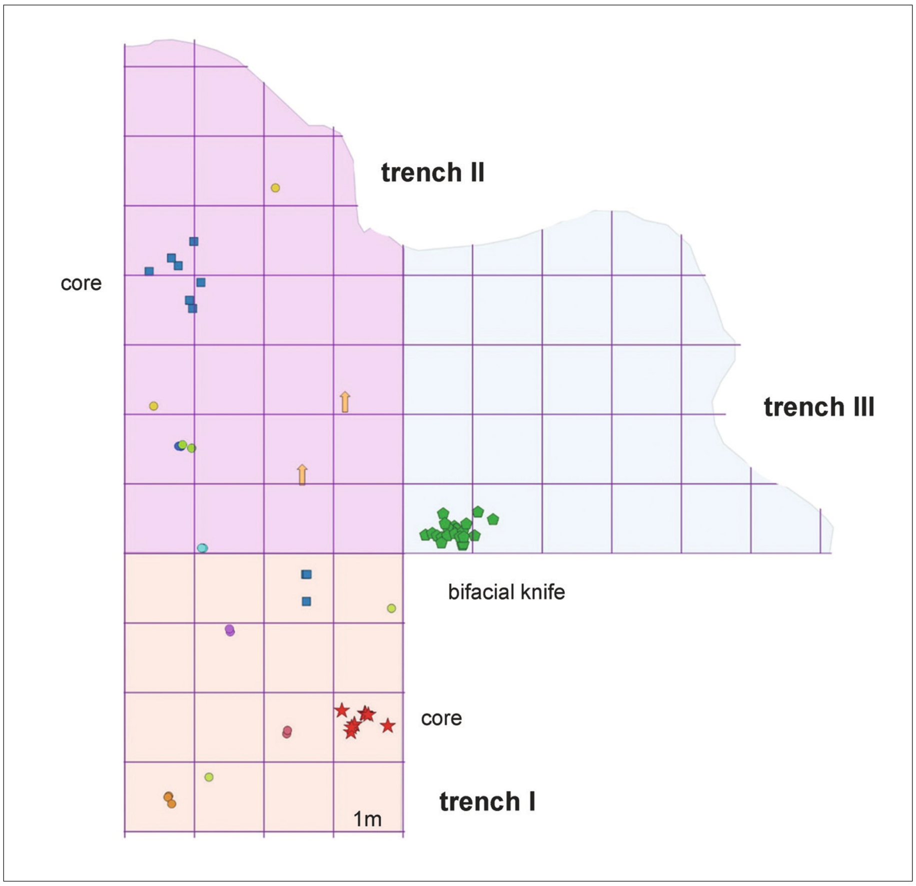

Fig. 12. Ciemna Cave, sector CK – spatial arrangements of refittings from the youngest Micoquian level (III).

Abb. 12. *Ciemna-Höhle, Sektor CK – Räumliche Verteilung zusammengesetzter Steinartefakte in dem jüngsten Micoquien Niveau (III).*

Cave – assemblage E & F (Cyrek et al. 2014), Wrocław-Hallera street – upper horizon (Wiśniewski et al. 2013), Bojnice III (Neruda & Kaminská 2013) and Kůlna Cave (Neruda & Nerudová 2014).

The environmental and cultural sequence from Ciemna Cave can be regarded as sealed with relatively well-preserved sediments accumulated under stable conditions. It provides a new possibility to reevaluate Micoquian settlements known from many sites in southern Poland like Wylotne Rockshelter, Okiennik Cave, Koziarnia Cave, Piekary, and Kraków-Wawel. It is also essential for understanding the Micoquian epoch as a whole.

Acknowledgements: The research reported in this paper was performed under grant No. UMO-2014/15/B/HS3/02219, "The Last Neanderthals in the Ciemna Cave" obtained from the Polish National Science Centre. We would like to thank the Director and the Scientific Committee of the Ojców National Park for their support. Radiocarbon dates were funded by National Science Foundation [Doctoral Dissertation Improvement Grant #1334615 and Graduate Research Fellowship Program Award #DGE-1144152], the Exilarch's Foundation, the DANGOOR Research Accelerator Mass Spectrometry Laboratory (D-REAMS), and the Max Planck-Weizmann Center for Integrative Archaeology and Anthropology.

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