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Identification of a fragment of an Early Bronze bone recovered from the Borownia striped flint mine in the Ostrowiec district (on the centenary of Polish research on prehistoric flint mining)

Abstract

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The site was discovered in 1921 and identified as a prehistoric striped flint mine in 1922. It is notable for its excellently preserved prehistoric industrial landscape, particularly discernible in the valley of the Kamienna river. It was excavated for the first time in 2017. In 2018, the site was nominated for inscription on the World Heritage List together with the Krzemionki Opatowskie mine. Flint artefacts and radiocarbon dates set its chronology as the Late Neolithic and the Early Bronze Age. No bones have been preserved from that period apart from a fragment of a long bone in two parts. Microscopic analysis of thin sections has identified the fragment as a bone of a red deer (*Cervus elaphus*). The article concludes with remarks about the 2019 centenary of research on prehistoric flint mining in Poland.

Keywords: striped flint mining, thin section microscopic analysis of bone, Late Neolithic, Early Bronze Age, Borownia, Krzemionki Opatowskie.

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Introduction

The Historical and Archaeological Museum in Ostrowiec Świętokrzyski (HAM) and the Institute of Archaeology at the Cardinal Wyszyński University in Warsaw (IA CWU), in co-operation with the Autonomous Workshop for Prehistoric Flint Mining at the Institute of Archaeology and Ethnology, Polish Academy of Sciences in Warsaw (AWPFM IAE PAS), excavated the Borownia prehistoric striped flint mine, which was entered into conservation documents as Ruda Kościelna 18 (AZP 84-72/10) in the Ćmielów commune, Świętokrzyskie province, from 3 July to 26 August 2017.

An outline of research on the Borownia mine

The site was discovered by Stefan Krukowski (1890–1982) and Jan Samsonowicz (1888–1959) during their survey of the valley and the surroundings of the Kamienna between the mouth of the river and Ćmielów, where they hoped to find "flint sites". The survey lasted from 16 September to 9 October 1921 (Krukowski 1921: 157–158; Samsonowicz 1923: 16).

Krukowski considered Borownia to be the most interesting of the archaeological sites identified on the Kamienna river. Returning there soon afterwards

to investigate it further, he collected 340 kg of "tools and spalls" from the surface. The researchers failed at first to recognise the place as a prehistoric flint mine; Krukowski interpreted it as "a Campignien workshop" (Krukowski 1921: 163; cf. Budziszewski 1999; Budziszewski and Michniak 1983: 152–153).

The alleged Campignien site in Borownia was identified correctly only after Samsonowicz discovered a flint mine in Krzemionki, south-west of the village of Magonie on 19 July 1922 (Samsonowicz 1923: 22–23). These two flint mines are situated at a distance of 7 km from each other, from the tourist route over the exploitation field in the Krzemionki Opatowskie Reserve to the best preserved north-western segment A of the Borownia exploitation field directly above the Kamienna valley (Fig. 1).

Borownia stands out among the prehistoric flint mines investigated in Poland to date because of its excellently preserved exploitation field with many visible shaft depressions surrounded by spoil heaps. The site ranks among the few European flint mines whose post-mining landscapes have survived until now in very good condition. In Borownia, this applies particularly to the north-western part of the site, where the bone fragment discussed here was found (Segment A; cf. Adamczak *et al.* 2011: 7, Fig. 1 and 2).

Because of attempts made from ca. 1931 to level an edge of the Borownia exploitation field so as to extend the adjacent farmland, an archaeological reserve encompassing the best preserved parts of the prehistoric mine was formed in 1934. The project had the support of Countess M. Broel-Platerowa, the owner of the land (Budziszewski 1999: 597; Budziszewski and Michniak 1983: 154).

Since its discovery, the site aroused considerable archaeological interest, first of all at the State Archaeological Museum in Warsaw and, in the second half of the 20th century, the Institute of Archaeology and Ethnology at the Polish Academy of Sciences in Warsaw and the Institute of Archaeology at the University of Warsaw, and recently, at the Institute of Archaeology at the Cardinal Wyszyński University in Warsaw (Sawicki 1948: 129; Krzak 1961: 29–44; Lech 1975: 140–141, 144–146; 1987: 114 and 125–126; Budziszewski and Michniak 1983: 152, 154–155, 164–167, 183–186; Borkowski 1992: 229; Budziszewski 1996: 87–89; Zalewski and Borkowski 1996; Adamczak *et al.* 2011; Radziszewska 2014: 168–174, 176–183). Until July

Fig. 1. The Borownia flint mine, Ostrowiec district. Segment A. Excavation 2017. A view of the eastern cut with the depression of the explored shaft A1. Photo by J. Lech.

2017, the Borownia mine was explored with non-invasive methods, mainly through surface surveys, but also geophysical and geotechnical investigation, which included airborne laser scanning, used by K. Radziszewska (2014).

The excavation, which began in July 2017, resulted primarily from the decision to nominate the Borownia mine, together with the Krzemionki Opatowskie and the Korycizna striped flint mines, as Polish heritage properties to be inscribed on the World Heritage List (*Borownia* 2018). At first, the plan was to nominate solely the Krzemionki mine. According to international experts on the World Heritage, however, there was a risk that such a nomination would be rejected in view of inscribing the Neolithic flint mine in Spiennes (Belgium) on the list on 30 November 2000 (Collet *et al.* 2008: 41). Experts both in Poland and abroad agreed that Krzemionki would stand a much better chance if the site were presented as a prehistoric region of striped flint mining together with the Borownia and the Korycizna mines and with the related settlement of the Funnel Beaker culture on the Gawroniec hill in Ćmielów in the Ostrowiec district. The decision was made at the end of March 2017 after consulting the National Heritage Board of Poland. The nomination for inscribing the Krzemionki Prehistoric Striped Flint Mining Region on the World Heritage List was submitted in Paris on 31 January 2018.

The excavation of the mine in 2017

The aim of the excavation of the Borownia mine was first of all to provide charcoal, which is usually found in sufficient quantities in exploration of prehistoric exploitation fields, for radiocarbon dating of the examined sections of the site. The project was supervised by Prof. Jacek Lech from the Institute of Archaeology of the CWU in Warsaw and the Archaeological Museum and Reserve "Krzemionki", a branch of the HAM, in co-operation with Artur Jedynak from the Museum in Krzemionki and Dr Dagmara H. Werra from the AWPFM IAE PAS. The excavation was carried out with the assistance of students from the Institute of Archaeology of the CWU, who had their student internship in Borownia or were employed there by the HAM.

The project involved two fragments of the exploitation field in segments A and D, several hundred metres apart, which had earlier been levelled and partly destroyed by various activities, some of them illegal. In segment A, which interests us here, a cross-shaped excavation unit was made, with its arms described as the northern, southern, eastern (Fig. 1) and western cuts. The arms were 10 m long except the southern one, which was only 6.5 m long, because of the extended root system of a clump of hazel, cut down at the beginning of the excavation (from the north, at the junction of cut S and the E-W trunk route descending westwards with the slope towards the Kamienna valley), and an old tree to the south, i.e. the centre of the exploitation field. The cuts were 2 m wide. The team uncovered and documented several prehistoric features no longer discernible at the surface, mostly shafts surrounded by limestone spoil (Fig. 2). Big angular limestone blocks from a prehistoric spoil heap in the eastern cut of segment A showed that the Borownia mineshafts, a few metres deep, had been sunk into solid limestone rock from which striped flint had subsequently been extracted. The team collected more than six thousand spalls and several interesting tools and blanks as well as hammers made of rocks other than flint, of different sizes and weights. The basic flint products at the site were initial forms or blanks of cutting edges with a lenticular cross section and adzes; other types of tools were only represented by isolated items.

Samples of charcoal and one fragment of bone were collected from organic matter. The bone was found at the eastern wall of shaft A1 [sections a, m.b 5(-80)] in a layer of loose fine limestone spoil bordering on a sand layer in the fill of the shaft at the depth of 190–210 cm on 14 August 2017, when the co-author of this article sampled the material for screening. The fragment survived in two parts in a thin layer of bluish loam which had flown down the eastern boundary of shaft A1 in the eastern cut of segment A (Fig. 2). The layer contained many flint chips and charcoal pieces, which were radiocarbon dated to Poz-95494, 3525 +/- 35 BP (i.e. 1575 +/- 35 bc) at the Poznan Radiocarbon Laboratory. After calibration, made with the OXCal software, the bone was dated to 1943–1751 BC. Several other flint mines exploited in the same period in the upper Vistula basin have been excavated by archaeologists and radiocarbon dated: Ożarów "Za Garncarzami", Wierzbica "Zele", Polany Kolonie II and Polany II (Herbich and Lech 1995: 502–504; Lech 1995: 469; Schild 1995: 484; Budziszewski 1997: 51–54; Lech and Leligdowicz 2003: 293, Table 1).

The bone fragment was situated in the first layer which had flown into shift A1 with heavy rain soon after the item had been discarded or after the first spring thaw in the following year. The material was carried to fine limestone spoil which had fallen from the spoil heap of shaft A1 or had been thrown in during the work on the adjacent shaft. The sample, which included charcoal, was contemporaneous with one of the phases of the exploitation of the striped flint mine in Borownia.

Fig. 2. The Borownia flint mine, Ostrowiec district. A view of the northern profile section of the eastern cut. On the left, the depression of the explored shaft A1; on the right, a profile section of the spoil heap of another shaft; at the bottom of the cut in the centre, the flown-in layer in which the bone fragment was found. Photo by J. Lech.

The radiocarbon dating of the sampled charcoal, the most important result of the excavation, helped to determine the chronology of the uncovered features as the Final Neolithic and the Early Bronze Age. Prof. Maria Lityńska-Zając's species analysis of the charcoal should make it possible to reconstruct the natural environment in the immediate vicinity of the shafts during the use of the Borownia mine.

Archaeological material collected from fields in the immediate vicinity of the mine during a surface survey carried out by the AWPFM IAE PAS (Adamczak *et al.* 2011) suggested that striped flint had been exploited in Borownia from the classic phase of the Funnel Beaker culture to the Early Bronze Age, as posited earlier by M. Zalewski and W. Borkowski (1996: 36–46, 49–50). The excavation in 2017 did not confirm that view, although the dating still cannot be ruled out because of the limited range of the investigation. Analysis of the recovered flint material has shown that the exploitation ought to be dated to the period from the Final Neolithic to the close of the second millennium BC in calibrated absolute chronology; the radiocarbon dating has determined the chronology as 2300–1500 BC, with intensive use of the mine between 2000 and 1700/1600 BC and the sporadic activity of prehistoric communities thereafter. The Borownia striped flint mine was partly contemporaneous with other flint mines in that part of Europe: the chocolate flint mines Polany II (Lech and Leligdowicz 1980: 151; Chmielewska 1988: 170–171; Herbich and Lech 1995: 502, 504), Polany Kolonie II (Schild 1995: 484) and Wierzbica "Zele" (Lech 1995: 469, 472–479; 1997: 102–103), the Ożarów flint mine at Za Garncarzami Site in Ożarów (Budziszewski 1997: 51), the mine complexes in *Krumlovský* Les in Moravia (Oliva 2010: 266) and Bečov in the north-western Czech Republic (Lech and Mateiciucová 1995: 277), as well as the Krasnaselsky and the Karpautsy mines in western Belarus (Gurina 1976: 127).

The significance of the Borownia mine in prehistoric flint mining in Europe was first pointed out at the international conference in Faro (Portugal) in 2016 (Lech and Werra 2016). A summary of the excavation in Borownia in 2017 was presented at the Second Archaeological Seminar in Krzemionki: Spring 2018, which took place at the Archaeological Museum and Reserve "Krzemionki" on 23 and 24 March 2018, and

at the 18th World Congress of the International Union of the Prehistoric and Protohistoric Sciences (UISPP) in Paris, during the session organised by the UISPP Commission on Flint Mining in Pre- and Protohistoric Times on 6 June 2018.

The uncovered bone fragment proved unsuitable for precise anatomical and species identification. Macroscopically, it could merely be described as a fragment of a long or flat bone of a specimen similar in size to certain species (Fig. 3). Consequently, it was subjected to microscopic examination.

The method of identification

Microscopic identification consists of examining the microscopic structure of bone: a thin section of the material is analysed under a polarising microscope in transmitted light. A fragment of the shaft of the long bone, several millimetres thick, is cut out across the long axis to obtain a section of compact bone containing osteons with Haversian canals in their centres (Lasota-Moskalewska 2008: 112–113). In this case, the thin section has been analysed by the method described in the publications of A. Lasota-Moskalewska (1979; 2005: 35; 2008: 112–117) and A. Lasota-Moskalewska and S. Moskalewski (1980). The method helps to determine whether the bone belonged to a domesticated animal or a wild animal and, to some extent, to identify the species.

This approach involves the description of the arrangement, density and shape of osteons, the index of their surface area which is a quotient of the total surface area of osteons on the total intersystemic (interosteonic, extraosteonic) surface area in the same field, and measurement of the shorter diameters of Haversian canals. The index of the surface area of osteons can be reliably used to distinguish domesticated and wild animals, as it has different values for these two groups: 0.40–1.58 for wild animals and 0.07–0.35 for domesticated animals (Lasota-Moskalewska 1979; 2008: 113, 116; Lasota-Moskalewska and Moskalewski 1980).

Results of the measurement of the shorter diameters of Haversian canals are different for individual animal species (Harsányi 1993: 87; Horocholyn 2013: 40–41, 107, 109, 111–112; Lasota-Moskalewska 2008: 116; Urbanová and Novotný 2005: 80). Human bones are the largest in diameter. It may be assumed that the shorter diameter of Haversian canals equalling 50 μm is the threshold between humans and animals (Urbanová and Novotný 2005: 83).

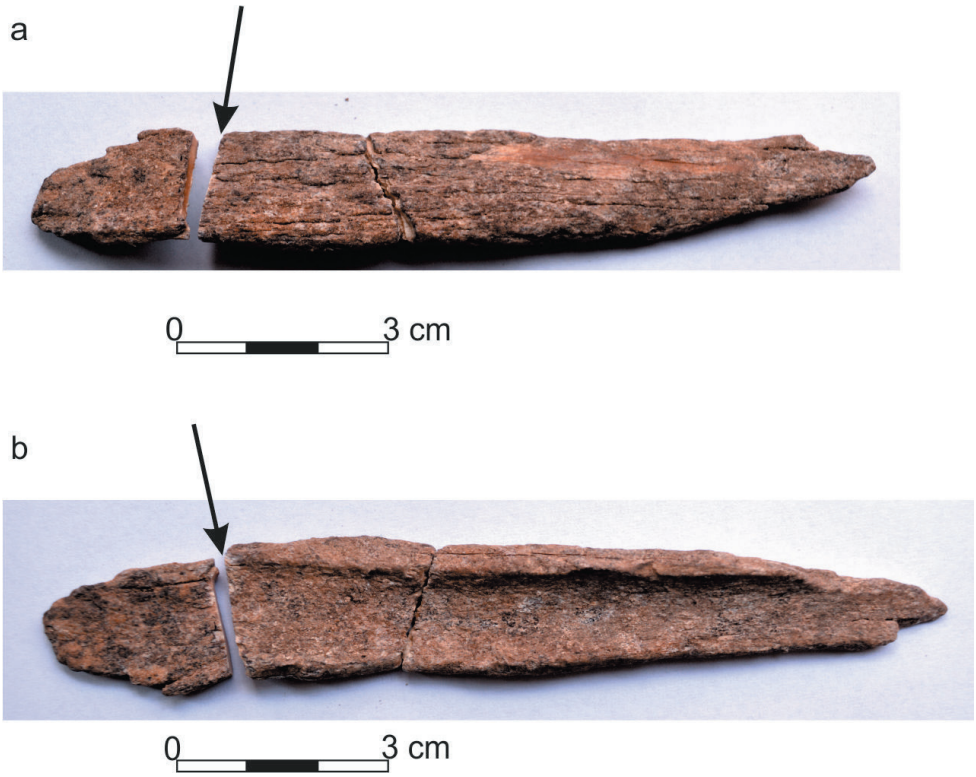

Fig. 3. The Borownia flint mine, Ostrowiec district. The bone fragment from the flown-in layer in shaft A1: a – view from the outside; b – view from the inside; the arrow indicates the direction of the cutting. Photo by A. Rauba-Bukowska.

The microscopic analysis was performed under a Nikon Eclipse LV100N POL polarising light microscope in the Institute of Archaeology and Ethnology at the Polish Academy of Sciences.

Results

The analysis of the bone fragment had two main stages: macroscopic and microscopic identification.

Macroscopic analysis

Macroscopic examination solely showed that the analysed material was a fragment of the shaft of a long bone (broken in two) which may have belonged to one of four species: human (*Homo sapiens*), horse (*Equus caballus*), cattle (*Bos taurus*) or red deer (*Cervus elaphus*). More precise identification was impossible.

Microscopic analysis

A thin section of the analysed bone fragment was examined under a polarising light microscope (Fig. 4). The analysis centred on two segments of the thin section, 0.77 × 1.16 mm (i.e. approx. 0.89 mm^2) each, containing osteons with Haversian canals. The osteons, round or slightly oval in shape, were densely packed and chaotically arranged (Fig. 5). In each segment, the shorter and longer diameters of the osteons were measured and their surface areas were calculated in the visual

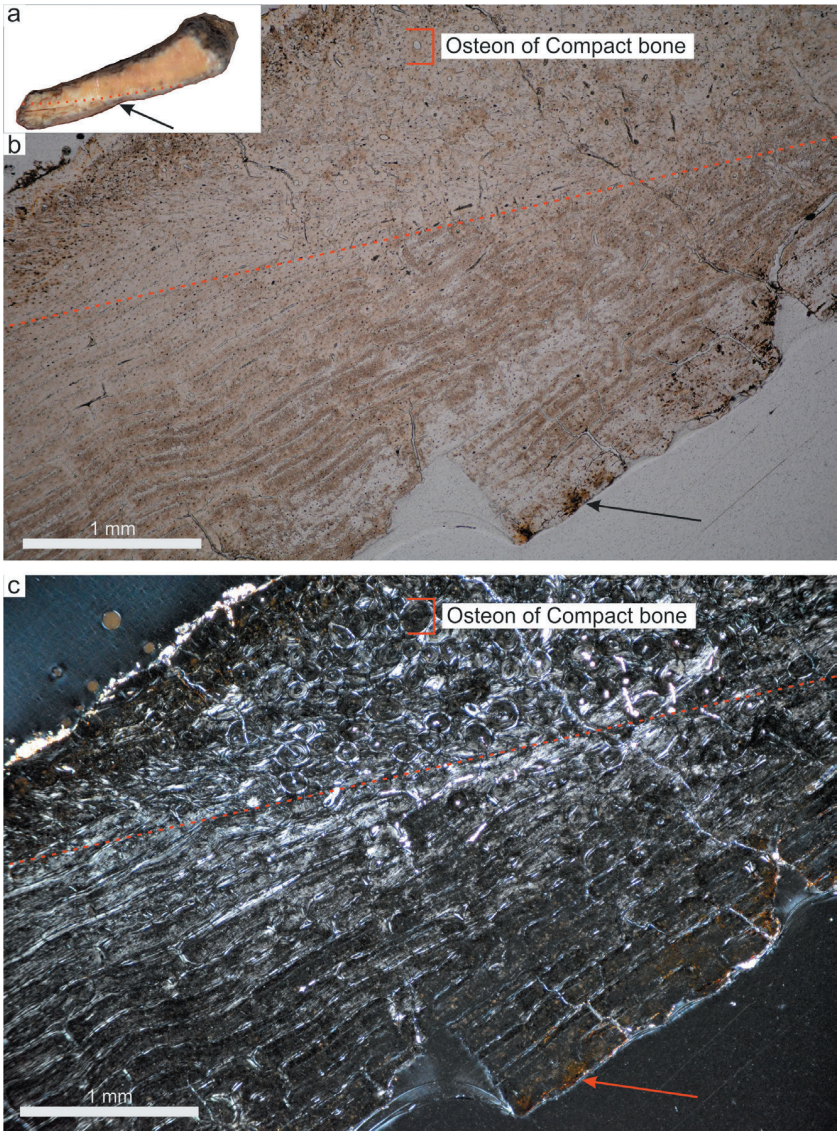

Fig. 4. The Borownia flint mine, Ostrowiec district. Cross section of the bone fragment under a microscope: a – cross section of the bone; b (1N), c (NX) – thin section. Above the dotted line, a segment with visible osteons and Haversian canals. The arrows indicate the outer surface of the bone. Photo by A. Rauba-Bukowska.

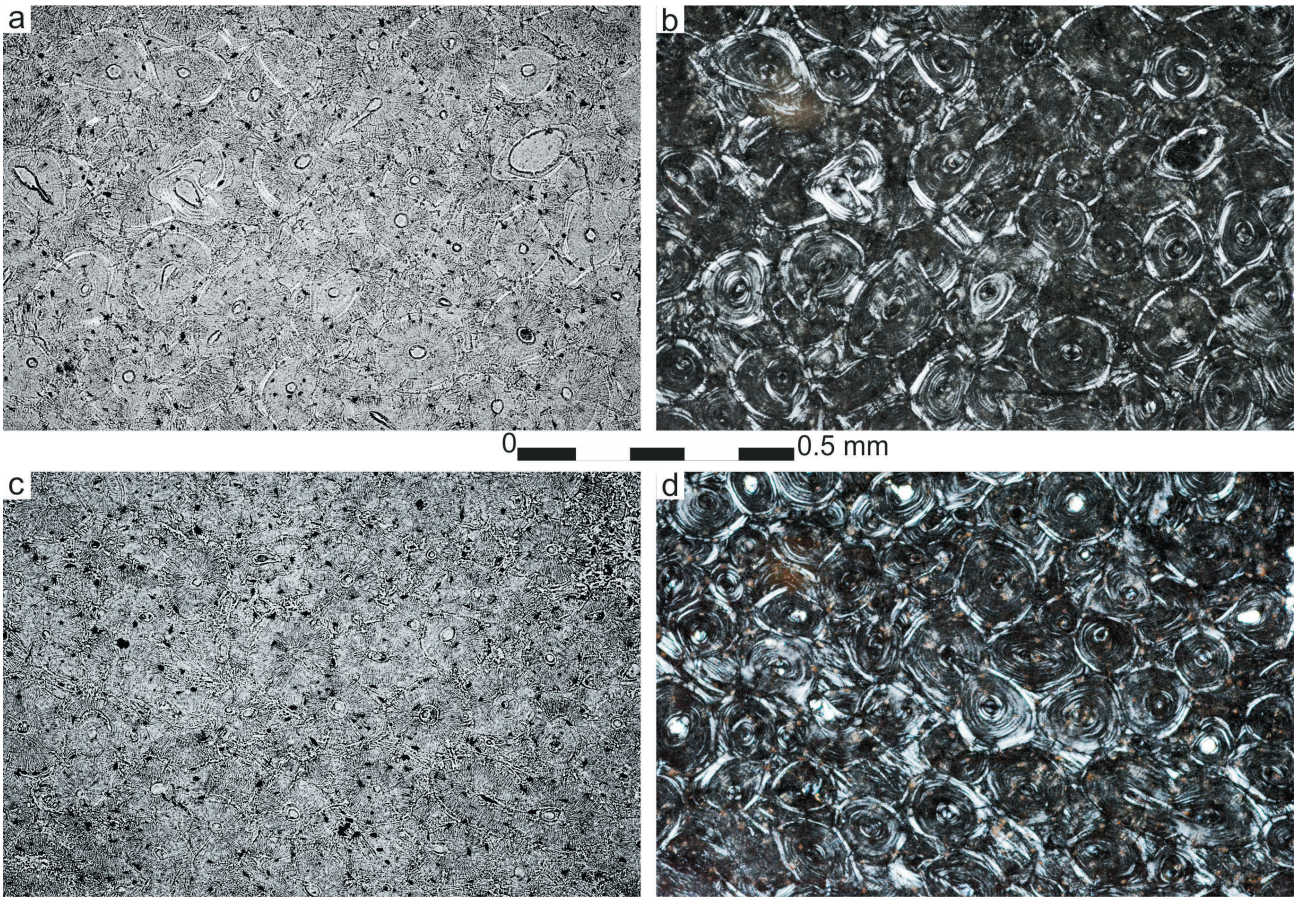

Fig. 5. The Borownia flint mine, Ostrowiec district. The bone segments examined under a microscope: a (1N), b (NX) – segment 1; c (1N), d (NX) – segment 2. Densely distributed round osteons visible in both segments. Photo by A. Rauba-Bukowska.

field covering 893 791,9 μm² (approx. 0.89 mm²; Table 1, Fig. 6). The calculated surface areas were added up and the sum was subtracted from the total surface area under examination to obtain the intersystemic surface area. The total surface area of all osteons visible in the examined segments was divided by the intersystemic surface area, giving the index of the surface area of osteons in each segment, 1.69 and 1.58 respectively (Table 1). Such indexes and the descriptive information presented above are characteristic of wild animals (Lasota-Moskalewska 2005: 35; 2008: 113–116).

Measurement of the shorter diameters of Haversian canals helped to identify the species. In the first analysed segment, the mean shorter diameter was 14.8 μm; in the second segment, it was 16.0 μm (Table 2). The results match the values 14.9–16.8 μm (Horocholyn 2013: 107) obtained for the white-tailed deer (*Odoceileus virginianus*), common in North America, and they are similar to values typical of the deer family, including the European red deer (*Cervus elaphus*; Urbanová and Novotný 2005: 80; Horocholyn 2013: 40).

Table 1. The Borownia flint mine, Ostrowiec district. The calculation of osteon area index in the examined segments of compact bone.

Examined areas (segments)	Examined area (μm²)	Total area of osteons (μm²)	Intersystemic area (μm²)	Osteon area index	Number of osteons (n)
1	893791,9	561851,1	331940,8	1,69	57
2	893791,9	547763,8	346028,1	1,58	63

Table 2. The Borownia flint mine, Ostrowiec district. The diameters of Haversian canals in the examined segments of compact bone; S.D. – standard deviation.

Examined areas (segments)	Minimum diameter of Haversian canals (µm)		Number of Haversian canals (n)
	Mean	S.D.	
1	14,8	5,9	20
2	16,0	3,9	43

Table 3. The Borownia flint mine, Ostrowiec district. The surface area of osteons and their diameters in the examined segments of compact bone; S.D. – standard deviation

Examined areas (segments)	Area of osteons (µm²)		Minimum diameter of osteons (µm)		Maximum diameter of osteons (µm)		Number of osteons (n)
	Mean	S.D.	Mean	S.D.	Mean	S.D.	
1	12817,4	6289,0	109,0	26,4	141,4	41,5	29
2	11376,3	4303,1	103,6	22,3	136,5	28,4	41

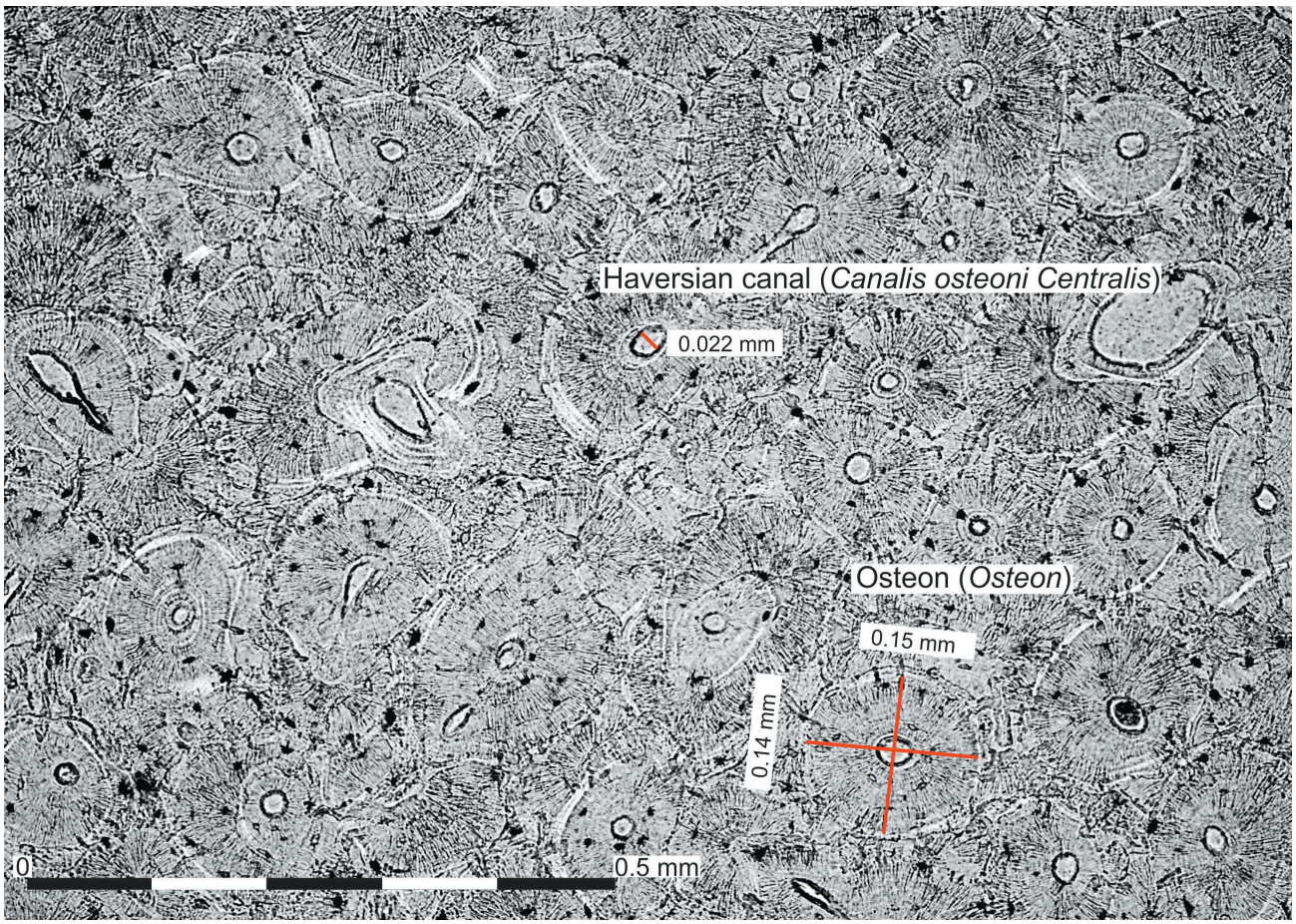

Fig. 6. The Borownia flint mine, Ostrowiec district. Segment 2 under a microscope. Examples of measurement of an osteon and a Haversian canal. Photo by A. Rauba-Bukowska.

Consequently, the analysed bone fragment may be assumed to be a part of the skeleton of a deer.

Summary and conclusion

The study concerned a two-part fragment of a bone recovered from the Borownia striped flint mine, contemporaneous with the exploitation of the local striped flint deposit. Morphological analysis of discrete flint finds as well as radiocarbon dating suggested that the item was related to flint mining of a Mierzanowice culture community. Macroscopic examination showed that it was a fragment of a long bone which may have belonged to one of four species: human (*Homo sapiens*), horse (*Equus caballus*), cattle (*Bos taurus*) or red deer (*Cervus elaphus*).

Microscopic analysis of a thin section of the bone, which involved measuring the diameters and the surface areas of osteons and the shorter diameters of Haversian canals, provided the index of the surface area of osteons in two examined segments, 1.69 and 1.58, respectively. These values, together with the recorded arrangement, density and shape of osteons, show that the bone fragment belonged to a wild animal. The measurement of the shorter diameters of Haversian canals, equalling 14.8 μm and 16.0 μm respectively, suggests that the bone came from the red deer (*Cervus elaphus*), common in Poland (Fig. 7). It is worth noting, however, that the diameters of Haversian canals are not stable for a given species due to interindividual and ontogenetic variability; moreover, their size depends on the type of bone and the area within the cortex (Lasota-Moskalewska 2008: 113).

In Małopolska, bones of the red deer have so far been identified at only two Early Bronze sites: the Babia Góra Site in Iwanowice and Site 9 in Szarbia (Makowicz-Poliszot 1997: 488, Table 1). The bones were found in materials related to the Mierzanowice culture (Kadrow 1991).

Archaeologically, the fragment of a long bone of the red deer from the Borownia flint mine may be a part of a mining or knapping tool. Alternatively, it may be a scrap left from a miners' or knappers' meal in the exploitation field; the workers may have bagged the animal themselves or acquired it in one of nearby Mierzanowice settlements. The fertile area of the Sandomierz Upland in the vicinity of the Krzemionki Opatowskie, Borownia and Korycizna mines (on the elevation above the Gierczanka river) was settled densely by communities interested in striped flint. This has long been emphasised in scholarship, but the relevant research has so far been disproportionate to the significance of the mines for the knowledge of the Middle and Late Neolithic and the

Fig. 7. The red deer (*Cervus elaphus* L.) from: Z. Grodziński (ed.) 1967: 476.

Bronze Age in the Vistula basin (Balcer 1963; Machnik 1977, 71–74; 1978, 40–44, 54; Wiślański 1979, 278–280; Kruk 1980, 56–58, 104; Bąbel 1979; 1985, 56–64; 2013a, 101–103, 108, 111, 119, 226–227; 2013b, 11–199; Lech 1987, 124–128; Kadrow 1995, 21–24, 30–32, 45–46, 77; 2001, 146–150; Budziszewski 1996, 104).

What is necessary is a long-term programme of systematic research on the large unexcavated segments of the Krzemionki Opatowskie mine and at least one shaft in the Borownia mine and the Korycizna mine, as well as the excavation and radiocarbon dating of these mines and the settlement linked to them. This preliminary archaeological investigation, recording and radiocarbon dating of the remarkable finds related to prehistoric striped flint mining, have long been sorely needed in Poland, which has fallen behind in this respect as compared to Western Europe and to the Czech Republic in the last twenty years (cf. Collet *et al*. 2008; Oliva 2010; Healy *et al.* 2014; Lech and Longworth 2014: 283; Bąbel 2015: 124–126). The excavation of the Borownia mine in 2017 is an example of such research.

We may only deplore the fact that excavation of the Korycizna mine, planned and prepared on a similar scale for 2018, had to be cancelled due to the lack of funding and it cannot be carried out in 2019 either. Polish archaeology of prehistoric striped flint mining has been grappling for years with insufficient survey of the mines and with severe underfunding of the Archaeological Museum and Reserve "Krzemionki Opatowskie". It is a sad paradox that when the nomination for inscription on the World Heritage List was being prepared, the Borownia mine which was nominated for the inscription, was disturbed to a considerable ex-

tent by construction work on a local road broadened and asphalted without notifying the Provincial National Heritage Protection Office and without prior archaeological investigation, and rescue excavation *post factum* proved impossible. The Korycizna mine, nominated for the inscription as well, has never been excavated or radiocarbon dated, though it is threatened with serious damage.

The year 2019 is the centenary year of Polish research on the prehistoric exploitation, processing and distribution of siliceous rocks. Despite numerous achievements in this field, it is by no means a happy centenary (cf. Bąbel 1975; 2015: 19–27; Lech 1975; 1992: 139–143; 1999: 78–80; Borkowski 1999; Borkowski and Migal 1999: 89–90; Florek 2014; Piotrowska 2014: 30–34; Potocka and Zdeb 2014: 374–377; Radziszewska 2014).

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