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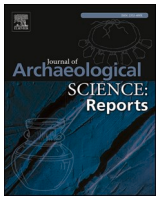

Cave funeral practices during the Roman and Migration Periods in the Cracow Upland, southern Poland

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ABSTRACT

Although caves have been used for funerary purposes almost since the dawn of time, there is very little evidence of such use in Central European *Barbaricum*. This paper presents newly obtained results from the Cracow Upland (southern Poland) concerning multiple skeletal remains that apparently share a similar third–fifth centuries AD chronology, corresponding to the Late Roman and Early Migration Periods. Multiple analyses have been performed to supplement archaeological data, including radiocarbon dating, osteoarchaeological analysis, ancient DNA research and isotopic analysis. The complex picture points towards unusual burial practices, which generally spanned from the third to the fifth centuries AD and involved a broad demographic, with no indication of selection based on an individual's biological profile. Isotopic analysis has also indicated the individuals' heterogeneity with regard to diet and local versus nonlocal origin. The results point towards the previously unrecognized unique role of caves in the Przeworsk culture, then present in southern Poland.

1. Introduction

Caves and rockshelters have attracted people since the dawn of time. Therefore it is not surprising that they hold numerous traces of human activities representing different fragments of the past. Many of them relate to late prehistory. This is also the case for the first half of the first millennium AD, a period which is well represented in the caves of Central Europe, e.g., in one of its largest karstic regions – the Cracow Upland (southern Poland; Fig. 1) (Mączyńska, 1970; Dobrzańska, 2006). Archaeological remains of the Roman and Migrations Period are known from nearly 50 caves and rockshelters there. These assemblages consist of pottery vessels, personal adornments, clothing elements and, in some cases, weaponry and coins (Table 1). The published data are, nonetheless, scarce and limited to background information (Godłowski, 1995; Dobrzańska, 2006) or descriptions of assemblages from a single cave (Mycielska and Rook, 1966; Mączyńska, 1970; Rodzińska-Nowak et al., 2000; Madyda-Legutko and Wojenka, 2020; Kontny et al., 2021).

In most previous research, it was commonly assumed that for the societies then forming the so-called Central European *Barbaricum*, the caves served mainly as shelters or hideouts for local communities (Godłowski, 1995; Dobrzańska, 2006; Mączyńska, 2020; see also Branigan and Dearne, 1992). However, our paper shows that this is an overly simplified picture, and caves could have had a much more profound meaning for these communities.

The purpose of this paper is to present the previously unrecorded phenomenon of depositing human remains in the caves of the karstic region of Cracow Upland during the Roman (from the turn of the eras until ca AD 375) and Migration Periods (late fourth century–second half of the fifth century AD). Our results are based on a series of radiocarbon dates encompassing human remains of at least 25 individuals unearthed

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in nine different caves and rockshelters, situated mainly in a restricted area of the Prądnik and Sąspówka river valleys. The radiocarbon dataset was combined with the results of archaeological and osteo-archaeological analyses, as well as genetic examinations and strontium, carbon and nitrogen isotope analysis. We aimed to answer whether the observed phenomenon indicates sepulchral cave use or reflects other types of ritual/non-ritual practices, and also whether it was related to the local communities or newcomers.

Human remains have frequently been found during excavations in caves. In Europe, this occurrence in caves is well attested, particularly for the Stone Age (Riel-Salvatore and Gravel-Miguel, 2013; Peterson, 2019; Ledogar et al., 2019) and to some extent for the Bronze and Early Iron Age (Parzinger et al., 1995; Orschiedt, 2012; Dowd, 2015). Nevertheless, little is known about caves as final resting places during later periods. This includes the first half of the first millennium AD. The available data from this period are very scarce and dispersed throughout Europe. The most well studied are the cave funeral activities in the British Isles, where a significant number of caves have yielded numerous radiocarbon-dated human remains covering this timespan (Dowd, 2015; Wilford, 2016; O'Regan et al., 2020). It is worth noting that in Great Britain, around two dozen caves contained human bones that have been linked to the period in question due to accompanying artefacts. In many of them, multiple individuals were found, e.g., 28 from Wookey Hole Cave, Somerset (Hawkes et al., 1978) and 40 individuals from Ogof-yr-Esgyrn, Brecon (Mason, 1977). Although slightly later, Spanish caves are also of particular importance, especially the area of Visigothic Cantabria, where several human bones produced radiocarbon dates from the seventh to the eighth century (Gutiérrez Cuenca et al., 2017; Arias et al., 2018).

In the rest of Europe, especially outside the Roman Empire, the evidence is scant, particularly in its central part (Fig. 1). From Sontheim Cave, Alb-Donau, Germany, the remains of 14 individuals were found (Schach-Dörges 2010), three of which were ^{14}C dated to the fourth and early fifth centuries AD (Wahl, 2010). Another date (third to fourth century AD) comes from a fragment of a human skull discovered in St. Prokop's Cave, Středočeský kraj, Czechia (Svoboda et al., 2004). While the dating of these remains is beyond doubt, other reliable examples from Central Europe are lacking due to a paucity of radiocarbon dates. This is also the case for Kaplnka Cave and Netopierska Cave, Banskobystrický kraj, Slovakia, where a considerable number of human bones were discovered in association with several Late Roman (early fourth century–ca AD 375) or Early Migration Period (late fourth–second half of the fifth century AD) artefacts (Bárta, 1955), but it is not clear whether they once formed closed assemblages; similarly in Temná Cave, Košický kraj, a human skeleton was found close to two leather purses containing Roman coins (Soják, 2005).

Lack of radiocarbon dating is also a problem for studying the numerous human remains discovered north of the Carpathians in the caves of the Cracow Upland (southern Poland; Fig. 2), a karstic region renowned for its rich speleological potential (Gradziński and Szelerewicz, 2004). During decades of archaeological surveys, these bones have been unearthed together with late prehistoric, medieval or post-medieval artefacts from mixed Holocene humic layers, commonly occurring in the topmost parts of the cave fills. Given the disturbed nature of these cave deposits and the fact that their archaeological content accumulated over a long time, the chronological position of the aforementioned human bones remained uncertain prior to the application of ^{14}C dating. Such analyses were lacking because the remnants of

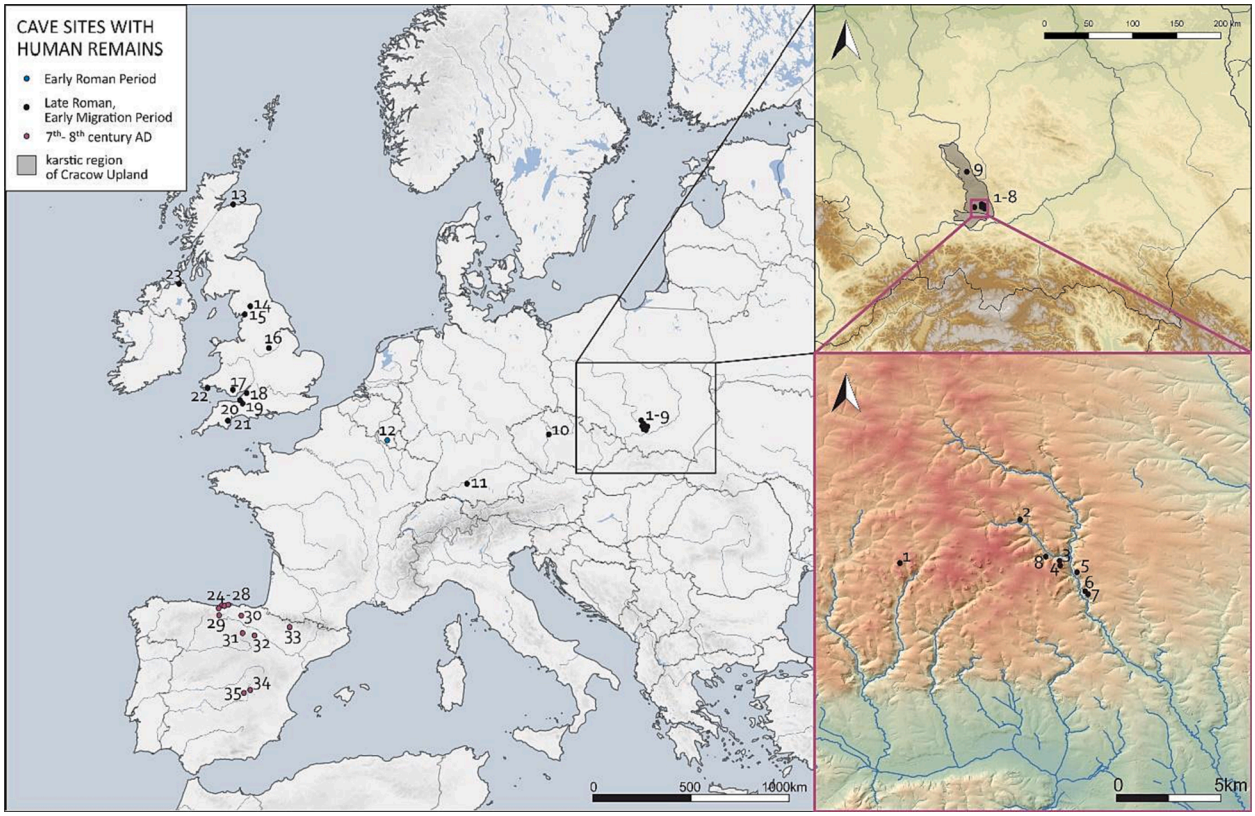

Fig. 1. The cave sites with radiocarbon-dated human remains mentioned in this text. 1. Żarska Cave; 2. Koziarnia Cave; 3. Łokietka Cave; 4. Boczne Rockshelter near Łokietka Cave; 5. Ciemna Cave; 6. Upper Cave at Ogrojec; 7. Boczne Rockshelter at Ogrojec; 8. Zbójecka Cave; 9. Kroczycka Cave; 10. St. Prokop's Cave; 11. Sontheim Cave; 12. Han-sur-Lesse Cave; 13. Sculptor's Cave; 14. Rawthey Cave; 15. Dog Hole Cave; 16. Robin Hood's Cave; 17. Lesser Garth Cave; 18. Fishmonger's Swallet; 19. Badger Hole; 20. Uphill Quarry Cave; 21. Three Holes Cave; 22. Dailight Rock; 23. Boat Cave; 24. Cudon; 25. Las Penas; 26. El Juyo; 27. La Garma; 28. Riocueva; 29. Cueva Larga; 30. Los Goros; 31. El Tejon; 32. Cuntrebia Leuade; 33. Foradada; 34. Mina Los Morceguillos; 35. Mina La Condenada (Svoboda et al. 2004; Wahl 2010; Warmenbol 2013; Wilford 2016; Arias et al. 2018; O'Regan et al. 2020).

Table 1
List of caves in the Cracow Upland where Roman/Migration Period artefacts and human remains, both radiocarbon dated and of unidentified chronology, have been found.

N°	Cave name, locality	Roman/Migration Period finds	Human remains	Human remains 14C dated to Roman/Migration Period	References
1	Żarska Cave, Żary	+	+	+	Wojenka et al., 2016
2	Koziarnia Cave, Ojców	+	+	+	Chmielewski, 1967
3	Łokietka Cave, Ojców	+	+	+	Rodzińska-Nowak et al., 2001
4	Boczne Rockshelter near Łokietka Cave, Ojców	+	+	+	Czarnowski 1914a, Godłowski, 1995
5	Ciemna Cave, Ojców	+	+	+	Mączyńska, 1970
6	Upper Cave at Ogrojec, Ojców	+	+	+	unpublished
7	Boczne Rockshelter at Ogrojec, Ojców	+	+	+	Czarnowski, 1914b
8	Zbójecka Cave, Ojców	+	+	+	Godłowski, 1995
9	Kroczycka Cave, Kroczyce	+	+	+	Mycielska and Rook, 1966
10	Okopy Wielka Dolna Cave, Ojców	+	+	–	Chochorowska, 2006
11	Potrójna Cave, Ojców	+	+	–	Chochorowska, 2006
12	Upper Wierzchowska Cave, Wierzchowie	+	+	–	Godłowski, 1995
13	Tunel Wielki Cave, Sąspów	+	+	–	Wojenka et al., 2017
14	Gorenicka Cave, Gorenice	+	+	–	Dobrzańska, 2006
15	Przechodnia Cave, Kobylany	+	+	–	Godłowski, 1995
16	Bezimienna Cave, Bolechowice	+	+	–	Godłowski, 1995
17	Główne Rockshelter at Kopcowa Skała, Ojców	+	+	–	Chochorowska, 2006
18	Dziewicza Cave, Łazy	+	+	–	unpublished
19	Mamutowa Cave, Wierzchowie	+	+	–	Zawisza, 1874; Godłowski, 1995
20	Na Łopiankach I Cave, Mników	+	+	–	Godłowski, 1995
21	Nad Matką Boską Cave, Czułów	+	+	–	Godłowski, 1995
22	Nietoperzowa Cave, Jerzmanowice	+	+	–	Römer, 1883; Dobrzańska, 2006
23	Jasna Strzegowska Cave, Strzegowa	+	+	–	Cyrek, 1995; Rybicka and Cyrek, 1997
24	Pod Oknem (Wisielca) Cave, Kroczyce	+	+	–	Rudnicki, 2017
25	Zegar Cave, Smoleń	+	+	–	Kowalski, 1951; Cyrek, 2009
26	Maszycka Cave, Maszyce	?	+	–	Godłowski, 1995
27	Sąspowska Wschodnia Cave, Sąspów	?	+	–	Madeyska, 1988
28	Sąspowska Zachodnia Cave, Sąspów	?	+	–	Madeyska, 1988
29	Bramka Rockshelter, Ojców	–	+	–	Chmielewski, 1988
30	Północne Rockshelter at Kopcowa Góra, Ojców	–	+	–	Rook, 1980
31	Dolne Zachodnie Rockshelter at Góra Koronna, Ojców	–	+	–	Chochorowska, 2006
32	Upper Cave at Okopy, Ojców	–	+	–	Czarnowski, 1902
33	Oborzysko Małe Rockshelter, Ojców	–	+	–	Rook, 1964
34	Pod Okopami Rockshelter, Ojców	–	+	–	Chochorowska, 2006
35	Główne Rockshelter at Zajęcza Skała, Ojców	–	+	–	Godłowski, 1995
36	W Stokowej Skale Rockshelter, Ojców	–	+	–	Godłowski, 1995
37	Bliźniacze Rockshelter, Bolechowice	–	+	–	Chochorowska, 2006
38	Borsucza Cave in Podskalany, Podskalany	–	+	–	Godłowski, 1995
39	Duża Cave at Mączne Skały, Biały Kościół	–	+	–	Dagnan-Ginter et al., 1992
40	Na Kawcu Rockshelter, Karniowice	–	+	–	Godłowski, 1995
41	W Okrążku Cave, Piekary	–	+	–	Jamka, 1939
42	W Uliczkach I Rockshelter, Czułów	–	+	–	Godłowski, 1995
43	Wielka Strąka Rockshelter, Kobylany	–	+	–	Godłowski, 1995
44	Wilczy Skok Rockshelter, Tomaszowice	–	+	–	Godłowski, 1995
45	Zawalona Cave, Mników	–	+	–	Alexandrowicz et al., 1992
46	Biśnik Cave, Smoleń	–	+	–	Cyrek 2002
47	Krucza Skała Cave, Kostkowice	–	+	–	Cyrek, 1994
48	Okiennik Cave, Piaseczno	–	+	–	unpublished
49	Towarna Cave, Kusięta	–	+	–	unpublished

human activity recorded within Holocene layers were rarely the subject of scientific attention, as primary research on caves was targeted at the Palaeolithic Age. This was the main reason why studies of the post-Pleistocene records from Polish cave sites were only of limited scope; they included the issue of Neolithic cave occupation (Rook, 1980) and, up to a certain point, the question of medieval and post-medieval cave usage (Wojenka, 2018a; 2018b).

Our paper presents is a first attempt at describing the complexity of cave use in the Central European Roman/Migration Period. In this area, the caves are concentrated mainly in patchily distributed karstic regions, such as the Cracow Upland, Moravian Karst in eastern Czechia, Slovak Karst and Aggtelek Karst in south-east Slovakia and north-east Hungary. Besides karstic regions with hundreds of caves, this type of site appears also in mountainous areas. In this paper, we focus on the Cracow Upland, analysing the human remains found its caves within the context of local settlement patterns and mortuary practices.

1.1. *Regional settlement context*

During the Roman and Migration Periods, the people of the Przeworsk culture, which stretched across wide areas of southern and central Poland, were thriving. They were mostly linked to a Germanic *milieu* (the tribes of Vandals/Lugii), but the Celts also had their share in the culture's constitution (Kolendo, 1999; Kolendo and Płóciennik 2015, 47–53). This Celtic impact was clearly visible, specifically in the Late Pre-Roman Period, i.e. in the second–first centuries BC (Maciałowicz, 2016; Maciałowicz et al., 2016, with further literature). Later, the Roman Empire strongly influenced Central Europe, including the

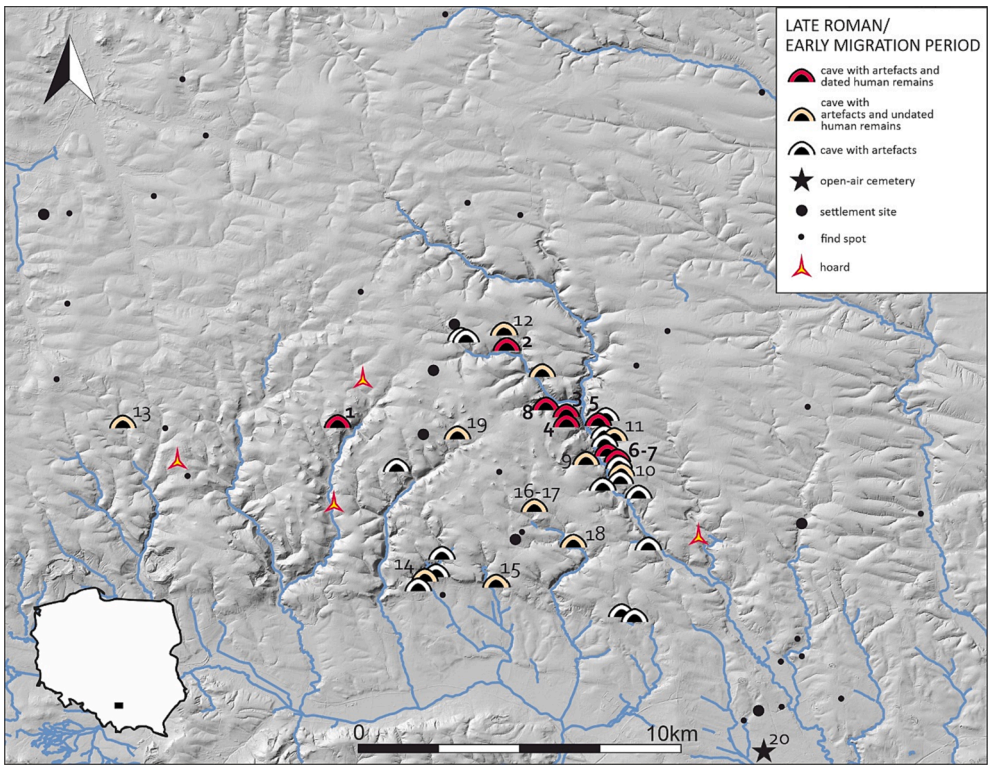

Fig. 2. Local settlement context of the cave sites discussed in this paper. **1.** Żarska Cave, Żary; **2.** Koziarnia Cave, Sąspów; **3.** Łokietka Cave; **4.** Boczne Rockshelter near Łokietka Cave; **5.** Ciemna Cave, Ojców; **6.** Upper Cave at Ogrojec, Ojców; **7.** Boczne Rockshelter at Ogrojec, Ojców; **8.** Zbójecka Cave, Ojców; **9.** Potrójna Cave, Ojców; **10.** Główne Rockshelter at Kopcowa Skała, Ojców; **11.** Okopy Wielka Dolna Cave, Ojców; **12.** Tunel Wielki Cave, Sąspów; **13.** Gorenicka Cave, Gorenice; **14.** Przechodnia Cave, Kobylany; **15.** Bezimienna Cave, Bolechowice; **16.** Upper Wierzchowska Cave, Wierzchowie; **17.** Mamutowa Cave, Wierzchowie; **18.** Dziewicza Cave, Łazy; **19.** Nietoperzowa Cave, Jerzmanowice; **20.** Modlniczka 2. For references, see Table 1.

Przeworsk culture. Among the characteristic elements of this cultural unit can be mentioned unfortified settlements of various sizes (Michałowski, 2003), some with traces of specialized production, e.g., the biggest smelting centres in the whole of Barbaricum were situated on the territory of the Przeworsk culture (Bielenin, 1992; Orzechowski, 2013; 2018; 2020). Flat open-space cremation cemeteries rich in iron apparel and weapons (the latter ritually destroyed) are typical here (Kontny, 2016, 188–199, with further literature). Based on the number of graves from separate phases and their opulence, it may be concluded that improvement in living conditions continued, and found its apex in phase C1 (i.e. AD 160–260). This is exemplified by the finds of numerous Roman imports (fibulae, glass beads, metal and glass vessels, gaming pieces, swords, etc.). At that moment, a peak in the number of graves is specifically observed for the early stage of the phase (subphase C1a, i.e. ca AD 160–230), as well as for the opulence of the grave furnishings (Kontny, 2016, 190, with further literature), with an increasing number of settlements and concomitant reduction in deserted areas between habitation clusters (Godłowski, 1985, 81–87). In subphase C1b (ca AD 230–260), a shift in burial rites began, which resulted in the gradual impoverishment of the grave equipment and therefore is not recognized as a sign of worsening economic conditions (Godłowski, 1985, 91–95, 99–104). Soon afterwards (mostly in phase C2, i.e. ca AD 260–310), single princely graves of the so-called Hassleben-Leuna horizon appeared in Central Europe, including on the territory of the Przeworsk culture (Werner, 1973; Becker, 2010). They mark the hierarchization of barbarian societies. Later on, a gradual settlement decrease marks areas in central Poland, but did not touch the southern part of the Przeworsk cultural area until the end of phase D1, ca AD 375–410 (Mączyńska, 2020). In southern Poland, the period starting in phase C1 was characterized by growing settlement density and their '*internal expansion*'. This heyday ended precipitously towards the end of phase D during the Migration Period (Godłowski, 1985; Godłowski, 1995). It needs to be emphasized that, apart from a few inhumation burials, cremation was the essential funeral rite of the societies representing the Przeworsk culture (see below).

Little is known about the settlement pattern of the Cracow Upland during the Roman and Migration Periods, since it has generally not attracted much attention from researchers (Dobrzańska, 2006). However, there are strong indications that when the societies of the Przeworsk culture were at their height, the area in question was situated on the western edge of a very dense concentration of settlements on the loess soils extending eastwards. Despite the poor state of research, the overall impression is that, compared with the latter, settlement in the vicinity of caves was definitely much sparser (see Dobrzańska, 2006). However, it is worth noting that, although in the Ojców area this practice is known only from surface surveys, some small settlement clusters of the Przeworsk culture were located not far from the caves (Fig. 2).

Importantly, in the aforementioned area, no cemeteries have yet been found, except for the Early Roman Period (turn of the eras–ca AD 160) graveyard at Giebułtów (Godłowski, 1961; Dobrzańska and Wielowiejski, 1997) and the atypical sepulchral site at Modlniczka—a bog deposit of burnt human remains, in use from the A2 phase of the Pre-Roman Period (120–60 BC) to the first half of the fourth century AD (Byrska-Fudali and Przybyła, 2010). Notably, these two sites are situated approximately 10–15 km from the caves (Fig. 2).

Consequently, a similar situation must be noted in the case of Kroczycka Cave, the northernmost cave site mentioned in this paper. Traces of open settlements or cemeteries are missing here, with the closest necropolis located approximately 10–12 km northwards at Lelów (Wagner, 2016) and slightly further north at Drochlin (Kaczanowski, 1987; Madyda-Legutko, 2017) (Fig. 2).

Last but not least, it is conceivable that some silver hoards and stray finds discovered both near Kroczycka Cave and near the caves situated in the northern part of the Upland are related to the time of unrest in the

Early Migration Period (Dymowski, 2007; Madyda-Legutko, 2011; Kaczanowski et al., 2017).

2. Background

2.1. Geological setting

The geological structure of the southern part of the Cracow Upland is relatively complex (Fig. 3). The oldest part of the substrate, exposed around Krzeszowice (about 15 km north-west of Cracow), is composed of Middle Devonian to Lower Carboniferous rocks represented chiefly by marine, fossiliferous limestones. Locally, there are small bodies of subvolcanic rocks that pierced this sequence during the Permian. The Palaeozoic substrate is gently folded and cut by faults. It is discordantly covered by flat-lying Middle and Upper Jurassic limestones, up to 200 m in thickness. The Jurassic strata's top surface is irregular on a large scale, with a relief formed by terrestrial corrosion and karst processes during the Cenozoic. It is overlain by a Pleistocene cover composed mainly of glacial till and loess. The former was formed by the South Polish Glaciations (Elsterian) whereas the latter accumulated during the last glacial period (Vistulian glaciation). The Pleistocene cover has been partly removed by erosion during the Holocene, and in consequence, Jurassic and Palaeozoic rocks are locally exposed. The youngest deposits in the area, represented by Holocene alluvial sediments, mostly sands with intercalations of clays, muds, peats and travertine, fill the valleys of rivers and streams.

A typical sediment infill of caves in the Cracow Upland exhibits a tripartite structure. It consists of a Holocene humic layer overlying Vistulian Pleniglacial loess strata (mostly dated to MIS 2; Krajcarz et al., 2016) and underlying Pleistocene clays (Madeyska, 1981). The thickness of the topmost humic layer varies significantly between different caves, from a couple of centimetres up to around 1–1.5 m, and almost always, as a rule, bears no traces of internal stratification.

The humic layer in many caves has to be understood as secondarily mixed and disturbed, and therefore their material content is stripped of archaeological context. Such cases appear to have resulted from diverse destructive activities in the recent past, made both by humans (e.g. treasure hunting or the guano mining industry, well documented in the second half of the 19th century) or by animals (e.g., badger setts). Regarding the guano mining industry, the extraction of humic sediments used as field fertiliser led to irreversible damage to several caves' upper levels (Kowalski, 1951).

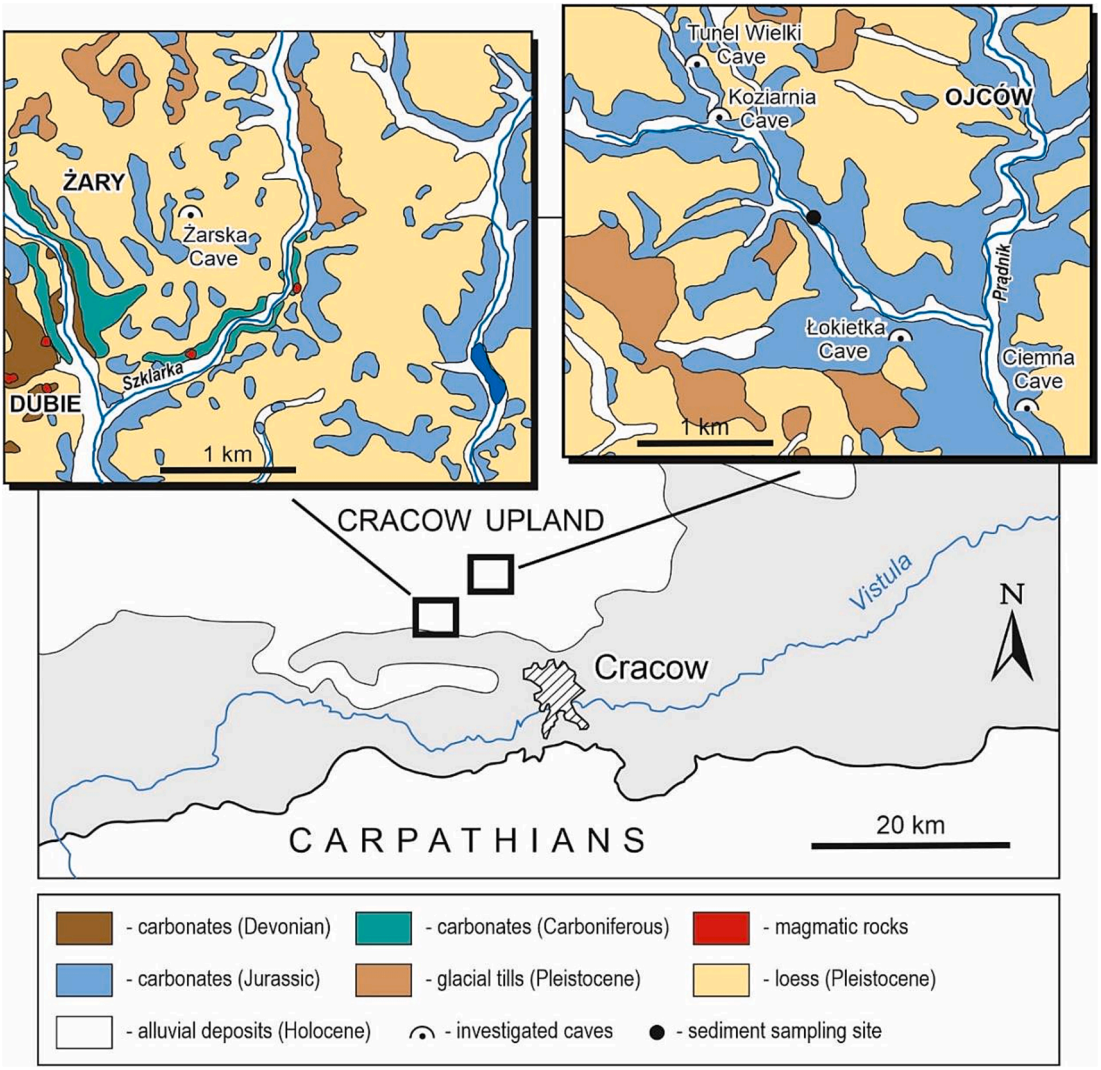

Fig. 3. Schematic map of the region around Cracow (southern Poland) with the location of the investigated caves. The main geological units, the Carpathians, the Cracow Upland and the Carpathian Foredeep (grey shading), are indicated. Detailed geological maps with the location of the investigated caves include information from the geological map of Poland.

2.2. Cave sites with human remains radiocarbon dated to the Roman and Migration Periods

2.2.1. Żarska Cave, Żary, Cracow district; Szklarka river basin, 50.09538° N, 19.42135° E

The cave is situated within the top part of Żary Gorge, ca 20 m above its bottom, within a group of limestone rocks. This is a large one-chambered cave, around 30 m wide and 15–20 m long, accessed from a wide but very low opening, not visible from a distance (Fig. 4:**1**). The site was explored in 1879 and was determined, for unknown reasons, as being archaeologically sterile (Ossowski, 1880). Archaeological excavations carried out in 2012 and in 2014–2015 allowed this statement to be verified (Wojenka et al., 2016) and in fact revealed a rich Holocene-era stratigraphic sequence, recently comprehensively examined (Wilczyński et al., 2020). The lower parts of this sequence yielded numerous Eneolithic Baden culture artefacts, while its upper section produced a large amount of Roman/Migration Period and later finds. Finally, it should be noted that the upper humic level yielded numerous disarticulated human remains, which produced radiocarbon dates appropriate to the Late Roman or Early Migration Periods (Wojenka et al., 2016) and contributed to the development of the research which is presented here in this paper. The human bones are now kept in the Institute of Systematics and Evolution of Animals PAS in Cracow.

Apart from numerous pottery sherds dated to the C1–D phases, Żarska Cave yielded an iron buckle with non-thickened frame, which is probably linked with the Przeworsk cultural environment. It is similar to types ML.H.3–8, occurring in phases C2–D (Wojenka et al., 2016, 198; Fig. 9:1; Madyda-Legutko, 1986, 72).

2.2.2. Koziarnia Cave, Ojców, Cracow district; Sąspówka Valley, 50.21914° N, 19.79588° E

The cave lies in Koziarnia Gorge, ca 10 m above its bottom, and comprises a 90 m long and up to 10 m wide corridor narrowing towards the end (Fig. 4:**2**–**3**), preceded by an arcade-like opening, nowadays quite sizeable (7.5 × 6 m), although much smaller in the 1880 s, when the first explorations took place at the site (Gradziński et al., 2020; Römer, 1883; 1884). Since then it has been excavated several times, revealing numerous archaeological finds from different periods, from the Palaeolithic up until the 20th century (Chmielewski et al., 1967). Notably, the unearthed archaeological assemblages included numerous finds from the Roman and Migration Periods (Godłowski, 1995; Dobrzańska, 2006).

Regarding Holocene-era human activity, the majority of the cultural assemblages was discovered in the cave entrance zone in the 1950–1960 s by W. Chmielewski, in the humus layer, which was over 1.5 m thick. The same stratum provided many stray human bones, which were

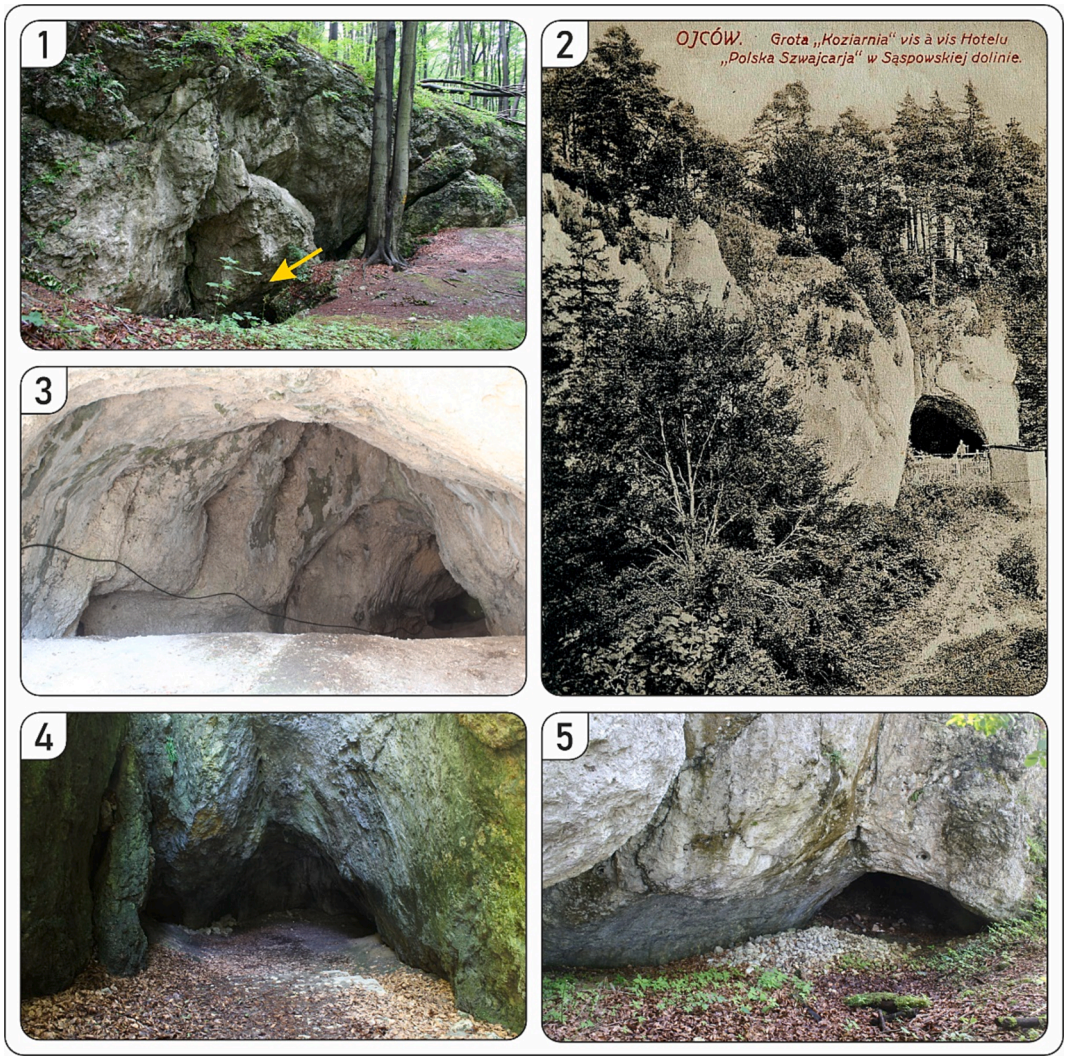

Fig. 4. Cave sites with human remains radiocarbon dated to the Roman and Migration Period. 1. Żarska Cave: the entrance (marked with an arrow), view from the north; 2. Koziarnia Cave: the entrance on a postcard from ca 1920; 3. Koziarnia Cave: the main chamber of the cave (view from the west); 4. Łokietka Cave: the entrance, view from the north; 5. Boczne Rockshelter near Łokietka Cave, view from the north-east.

recently recognized among the faunal assemblage stored in the Institute of Systematics and Evolution of Animals PAS in Cracow. The archaeological assemblages are partly kept in the Institute of Archaeology and Ethnology, Polish Academy of Sciences.

In Koziarnia Cave, precisely dated artefacts were few. Worth mentioning is a massive bronze buckle with a frame thickened on one side (Fig. 5**:10**), representing type ML.H.15 (Chmielewski et al., 1967, 54, Fig. 25:12; Madyda-Legutko, 1986, 65, Pl. 19:15). This type is well known in the *millieu* of Przeworsk culture, especially at sites placed within the Liswarta basin (southern Poland), such as the layered

Fig. 5. Selection of Roman and Migration Period finds from the studied caves. 1–6: Ciemna Cave; 7–10: Koziarnia Cave; 11: Żarska Cave; 12–16: Kroczycka Cave; 17–27: Łokietka Cave. 1–4, 10, 12, 16 – bronze; 5 – copper alloy; 6, 8–9, 18–27 – glass; 7, 13 – clay; 11 – iron; 14 – carnelian; 15 – bone; 17 – amber. After: Römer, 1883; Mycielska and Rook, 1966; Chmielewski, 1967; Mączyńska, 1970; Cyrek, 1997; Wrzesiński, 2006; Wojenka et al., 2016; Madyda-Legutko and Wojenka, 2020; Kontny et al., 2021.

cemeteries of the *Dobrodzień* type or the necropolis in Opatów, Kłobuck district, in the last phase of its use early in phase D (Madyda-Legutko, 1986, 65, Table 7; Madyda-Legutko, Rodzińska-Nowak and Zagórska-Telega, 2011, 28). The cave also yielded two fragments of an iron sheet in the shape of an arc segment bent up. Although there are no direct indications of their function, one may wonder if these were not parts of a box-shaped ferrule from a large buckle characteristic of the Migration Period (Kontny and Mączyńska, 2015, 250–253, Figs. 9–11; Kontny et al., 2015, 35–37), albeit similar ferrule construction (which possibly served for keeping organic amulets or fragrances) appeared as early as phase C2 (Kontny and Rudnicki, 2020, 525–526). Among the finds from Koziarnia there are also two glass beads similar to types TM 266–271, which were in use especially during phases C1–D (Römer, 1884, 37, Fig. 5:1, 2; Tempelmann-Maczyńska, 1985, 21, 53, 58, Pl. 48, Table 8), and a clay cylindrical rattle with a handle and pea seed inside, which was radiocarbon dated to 1705 ± 30 uncal BP (Kontny et al., 2021). Much less certain (see above) is the moment of deposition of a silver denarius of Antoninus Pius, minted in AD 139 (Römer 1884, 39–40, Pl. VI:7; Kunisz 1985, 154, Kat. 171; Dymowski 2007, 73).

2.2.3. *Łokietka Cave, Ojców, Cracow district; Prądnik stream valley; 50.20169° N, 19.81876° E*

The cave lies at the top part of Mt Chełmowa, ca 120 m above the valley of the Prądnik river. This is one of the most recognizable (first mentioned in 1691) and longest (320 m) caves in Poland. It consists of four large chambers, following one after another and linked with narrow corridors, in most cases high enough to stay upright (Fig. 4**:4**). The site was archaeologically explored several times since 1871 and produced data on its multi-cultural occupation. Understandably, due to the state of publication and the availability of the assemblages, of major importance are the results of more recent fieldwork carried out in 1998–1999 by K. Sobczyk and V. Sitlivy, and in 2015 by M. Wojenka and J. Wilczyński, which were conducted inside a wide niche in the main corridor, roughly 10 m from the cave's mouth. As demonstrated by these excavations, the earliest finds are as early as the Middle Palaeolithic (Sobczyk and Sitlivy, 2001a; 2001b), but the majority may be attributed to the series of Holocene humic layers, mostly the Neolithic, Roman and Migration Periods, as well as later finds (Rodzińska-Nowak et al., 2002). The same strata provided a large number of disarticulated human bones (stored in the Institute of Systematics and Evolution of Animals PAS in Cracow), which were described, sampled and examined for the purposes of this paper. The archaeological assemblages from Łokietka Cave are kept in the State Archaeological Museum in Warsaw, Archaeological Museum in Cracow and Institute of Archaeology, Jagiellonian University, Cracow.

Łokietka Cave yielded numerous artefacts dated to phases C1–C3/D, including pottery fragments (Rodzińska-Nowak et al., 2001), a few glass beads (Fig. 5**:18**–**27**) of types TM 104–107, as well as an figure-eight-shaped amber bead of type TM 471c, dated to phases C1a–D (Fig. 5**:17**; Tempelmann-Mączyńska, 1985).

2.2.4. *Boczne Rockshelter near Łokietka Cave (Polish: Schronisko Boczne przy jaskini Łokietka), Ojców, Cracow district; Prądnik Valley, 50.20184° N, 19.81901° E*

A small cavity ca 11 m wide and 3 m high, situated in the top part of Mt Chełmowa, ca 120 m above the Prądnik river valley. The rockshelter is situated directly left of the entrance to Łokietka Cave (Fig. 4:5). It has a form of a niche with three branches, two of them shallow, while the third is a 1 m high corridor, with a surface slightly elevating inwards (Gradziński et al., 2020).

The site has been excavated twice, first in 1899 and 1910–1911 by S. J. Czarnowski and then in 1999–2000 by K. Sobczyk and V. Sitlivy. It is worth noting, however, that all the humic layer was removed from the rockshelter during Czarnowski's excavations. The layer was several dozen centimetres thick and yielded numerous artefacts from late prehistory and historical periods but, in the light of Czarnowski's publications (1914a) and the search query made at the State Archaeological Museum in Warsaw, the items linked with the Roman or Migration Periods are few. The human bones and the artefacts excavated in 1910–1911 are kept in the State Archaeological Museum in Warsaw.

Only one artefact may be related to the Roman/Migration Period with certainty—a glass bead of TM 91a type as defined by Magdalena Tempelmann-Mączyńska (Tempelmann-Mączyńska, 1985). Worth noting is, however, an iron head of a polearm comparable with specimens of XXIII.2 type according to Piotr Kaczanowski (Kaczanowski, 1995). Its connection to the Przeworsk culture is very likely (but see the comments above), and, if so, it may be relatively early in date—similar objects appeared from phase C1a, although they mainly occurred during phase C2 and C3–D (Kaczanowski, 1995).

2.2.5. *Ciemna Cave, Ojców, Cracow district; Prądnik Valley, 50.19693° N, 19.83174° E*

Ciemna Cave is considered one of Poland's most recognizable caves; it was recorded in written accounts as early as 1691. It is situated near the top of Mt Koronna, ca 60 m above the valley of Prądnik. It is worth noting that Ciemna Cave *sensu largo* is a spacious cave system comprising the sizeable main chamber (Fig. 6**:1**) and the roofless part situated in front of the chamber—the so-called Ogrojec, with adjacent roofed sections of Oborzysko Wielkie and Tunel (Fig. 6**:2**). The main chamber is 88 m long, 10–23 m wide, and ca 8–10 m high. Access to it is currently via a small opening, ca 1 m high (Gradziński et al., 2020).

Since 1871 the site hosted several excavation campaigns, the majority of which were focussed in the Ogrojec and Oborzysko Wielkie. Of particular importance were the large-scale excavations of S.J. Czarnowski at the turn of the 20th century, which were focussed on the uppermost humic layers producing, among other finds, dozens of pottery fragments and metal objects dated to the Roman and Migration Periods (Czarnowski, 1924; Mączyńska, 1970). Similarly dated finds were also discovered during the later excavations of S. Krukowski in 1918–1919 (Madyda-Legutko and Wojenka, 2020) and S. Kowalski in 1963–1968 (Chochorowska, 2006). In 2007, a new archaeological campaign started, led by P. Valde-Nowak and which—for the first time—aimed to determine the scale of the settlement processes inside the main chamber (Valde-Nowak et al., 2014). All the above-mentioned excavations led to the discovery of numerous human remains linked stratigraphically with the topmost humic layers. The vast majority was unearthed in the Ogrojec and Oborzysko Wielkie (Czarnowski, 1924). However, the remains we are concerned with in this paper were recognized inside the main chamber in 2007. The archaeological material unearthed during the multi-seasonal excavations are kept in the State Archaeological Museum in Warsaw and the Archaeological Museum in Cracow. Radiocarbon dated human bones used for the purposes of this paper are stored in the Archaeological Museum in Cracow.

Ciemna Cave (Ogrojec/Oborzysko Wielkie) yielded the earliest metal object linked with the Roman Period from the analysed sites. It is an iron spur of type F.3a according to Jerzy Ginalski, dated to the phase C1 (Mączyńska, 1970, 205, Pl. I:6; Ginalski, 1991). An early date can also be assigned to an iron C-shaped pendant threaded on a wire loop, and another pendant of crescent form, made of bronze (Mączyńska, 1970, 204, Pl. I:3, 24). Such pendants are recognized in the Przeworsk cultural area from contexts of phase C1a, occurring also in C1a–C2 phases in the Wielbark culture and—incidentally—in Jutland during phase C2 (Mączyńska, 1970, 204; Natuniewicz-Sekuła & Okulicz-Kozaryn, 2018, 2011, 76, 80, Pl. CVII:5–7, CXVII:9; Przybyła, 2018, 400, Fig. 11/7:1). Also worth noting is a silver denarius of Marcus Aurelius issued in AD 176–177 (Mączyńska, 1970, 202, Fig. 3; Dobrzańska, 2006, 521), although it might have come to the cave much later, since Roman coins from the first and second centuries were in use in the territory of present-day Poland continuously until the turn of the sixth century, while in the Empire they were already out of circulation in the third century (Bursche, 2005, 203–205). The remaining part of the assemblage from this cave is considerably younger. It consists of an iron brooch A.158 type (Dobrodzień variant), four bronze brooches of A.158

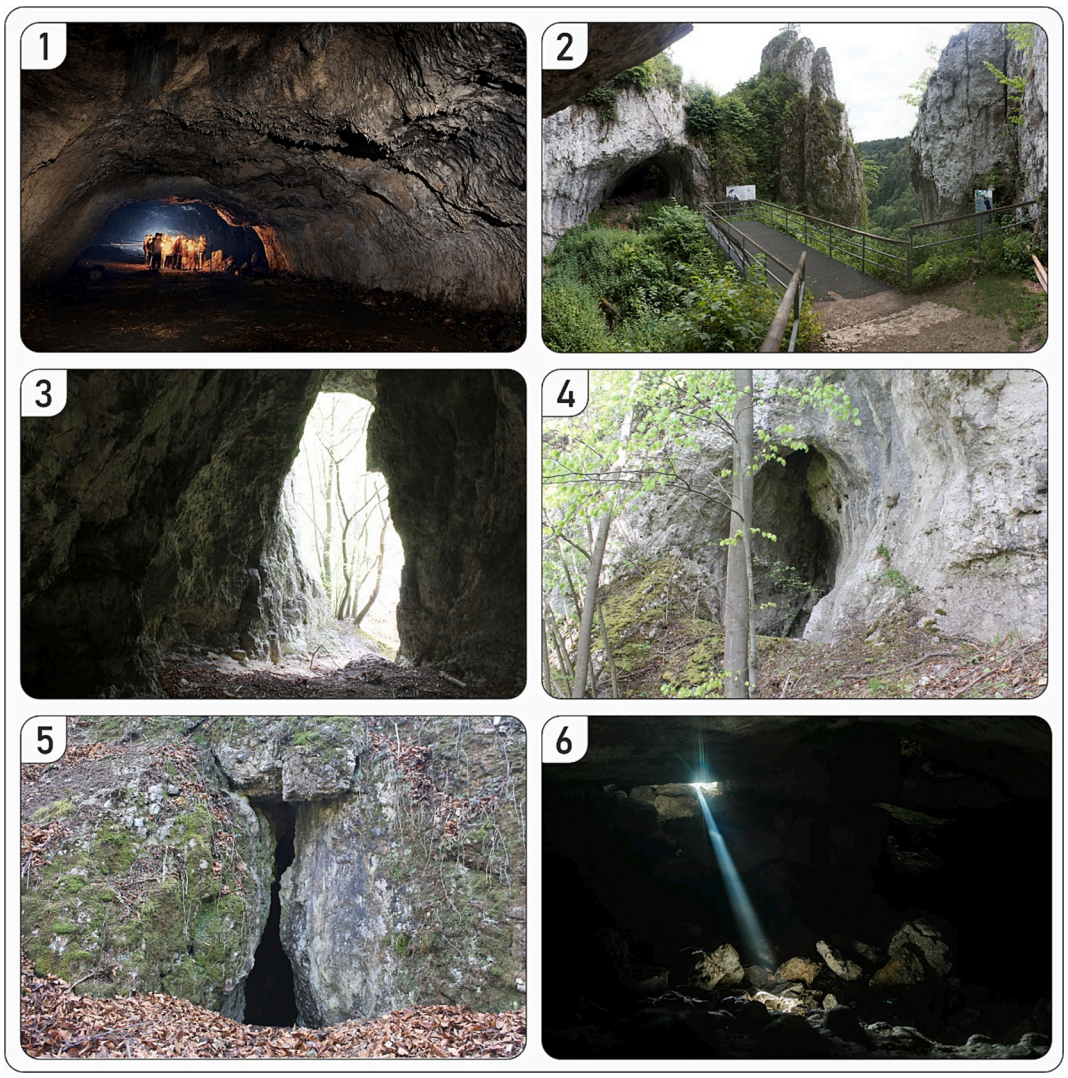

Fig. 6. Cave sites with human remains radiocarbon dated to the Roman and Migration Period. 1. Ciemna Cave: the main chamber, view from the north-east (courtesy of R. Cieślik); 2. Ogrojec and Oborzysko Wielkie by Ciemna Cave: view from the west (courtesy of D. Stefański); 3. Upper Cave at Ogrojec: the north-west entrance; 4. Boczne Rockshelter at Ogrojec: the entrance, view from the south-west; 5. Zbójecka Cave: the main entrance, view from the west; 6. Kroczycka Cave: a view inside.

type (Ojców 3 variant) and a pin and a fragment of another bronze A.158 brooch (Mączyńska, 1970, 201, Pl. I:1, 18–21). All the better-preserved specimens belong to phase D1 (Jakubczyk, 2014, 146). The remaining objects recovered from this part of the cave, such as a bronze strap-end of ML.VI.12.2 type (Mączyńska, 1970, 202, Pl. I:22; Madyda-Legutko, 2011, 95), an iron buckle with thickened frame (Mączyńska, 1970, 204, Pl. II:1) and—possibly—two anchor-shaped iron suspension mounts from a wooden bucket (Mączyńska, 1970, 205, Pl. I:7–8; Szydłowski, 1977, 103–110), may be viewed in the broader time range of phases C3–D (likely D1).

The youngest precisely dated object from Ciemna Cave (Ogrojec/Oborzysko Wielkie) is a copper-alloy decorative plate-like strap-end from the D2 phase, representing the *Sösdala-Untersiebenbrunn* style (Madyda-Legutko and Wojenka, 2020; see below).

Notably, a similar dating (phase C3–D) is applicable to some objects recovered from Ciemna Cave's main chamber (as yet unpublished), comprising a lining of a comb with a bell-shaped handle (Godłowski, 1970, 26–27), a few dozen glass and amber beads and at least two miniature axe-pendants of types 3 and 5 according to Kokowski. The latter two objects may be dated to phases C2–D (Kokowski, 1998, 100–102). They are characteristic of the Gothic environment, including the Post-Chernyakhov and Sântana de Mureş cultures (Magomedov, 2001, 71, Fig. 74:11). However, the first has a broader range and occurs in the Elbe drainage and Przeworsk cultural areas, as well as in the Sarmatian and even the Western Baltic cultures (Kokowski, 1998, Fig. 7, no. cat. 49; see recently—Florek, 2008; Belevec, 2016; Lasota-Kuś & Madyda-Legutko, 2018, 299–301, Fig. 3:3–4; Natuniewicz-Sekuła and Sekuła, 2018, 516–517). The type 5 axe-pendant was, asides from the Gothic environment, popular in the middle Danube and Tisza drainage areas (Kokowski, 1998, 101, Fig. 9); however, it is also known from the Przeworsk culture (Lasota-Kuś & Madyda-Legutko, 2018, Fig. 3:1, 5), including the area of the Cracow Upland (see the limestone monadnock at Podzamcze, Zawiercie distr.; Muzolf, 1997, tab. VI:3).

2.2.6. Upper Cave at Ogrojec (Polish: Jaskinia Górna w Ogrojcu), Ojców, Cracow district; Prądnik Valley, 50.18100° N, 19.83894° E

The cave is situated ca 50–60 m above the bottom of the valley, and has the shape of a wide and large tunnel-like corridor, access to which is via three openings (Fig. 6:3). The lower opening is the largest (ca 6 × 10 m) and leads to the main chamber, where the floor steeply rises up to the rocky threshold leading to the upper cave's opening (6.5 × 5.5 m). The third opening is situated in the ceiling (3.5 × 0.9 m). The overall dimensions of the cave are 26 × 2–7 m. The cave is dry and airy (Gradziński et al., 2020).

Both Upper Cave at Ogrojec and the nearby Boczne Rockshelter at Ogrojec were examined archaeologically in 1901–1902 by Stanisław Jan Czarnowski (1914b). In the humic layer (1–1.5 m thick) he found numerous traces from different periods of prehistory and historical times, but none of them can be associated with the Roman or Migration Periods. The archaeological assemblages and human bones from the cave are stored in the State Archaeological Museum in Warsaw.

2.2.7. Boczne Rockshelter at Ogrojec (Polish: Schronisko Boczne w Ogrojcu), Prądnik Korzkiewski, Cracow district; Prądnik Valley, 50.18110° N 19.83903° E

The rockshelter is a small niche situated ca 50–59 m above the valley, maximally 16 m long, but this decreases into a small chamber ca 3–4 × 1.5 m wide (Fig. 6**:4**). The cavity has two openings—the lower is large, ca 4 × 5.8 m wide and easily accessible, whereas the upper is smaller and is reached via a small chimney open to the rock surface. It is light and dry. Importantly, the rockshelter is situated only a few metres north of Upper Cave at Ogrojec (Gradziński et al., 2020). Together with the latter site, Boczne Rockshelter at Ogrojec was excavated in 1901–1902 by Stanisław Jan Czarnowski, who unearthed dozens of pottery pieces, flint, bone and metal objects while exploring the uppermost humic level, ca 0.7–0.8 m thick (Czarnowski, 1914b). Notably, for the most part these finds correspond with the Neolithic and Middle Ages. Apart from a single younger or late Roman Age/Migration Period pottery find there is only one single artefact which may be conditionally dated to the period in question— an iron head of a polearm of II.1 type as defined by Piotr Kaczanowski (Czarnowski, 1914b, 46, tab. VII:4). Such forms frequently appear in the Przeworsk culture from the Early Roman Period to phase C1a (Kaczanowski, 1995, 15), although similar objects incidentally appear later, during the Middle Ages (*cf.* Chodyński, 2019). Both human bones and the artefacts excavated in 1901–1902 are kept in the State Archaeological Museum in Warsaw.

2.2.8. Zbójecka Cave, Ojców, Cracow district; 50.20459°N, 19.81354° E

The cave is situated on the right slope of the so-called Jamki Gorge, not far from the valley of Sąspówka—a main tributary of the Prądnik river. It is characterized by three entrances to a short, cramped, narrow and descending passage, leading to a small chamber which branches out into two corridors, the right of which is narrow (ca 2–5 m), relatively high (3–4 m) and long (the total length of the cave is 189 m; see Gradziński et al., 2020). Worth noting is the main entrance to the cave, which is around 1.6 m high and narrow (Fig. 6**:5**).

This is one of the earliest Polish caves ever examined, but only through amateur excavations, which took place mainly in the cave chamber, in 1871 (J. Zawisza and A. Ślusarski) and 1872 (F. Römer). The excavations produced several artefacts, mainly from the Neolithic and the Roman Age as well (Zawisza, 1871; Römer, 1883; 1884; Rook, 1980). Notably, the 1870 s excavations were preceded by a series of accidental discoveries of human bones made by local people (e.g. Jastrzębowski, 1854). The archaeological assemblages from Zbójecka Cave are stored in the National Museum in Wrocław. The artefacts found in **Zbójecka Cave** have been extensively described by Kot et al. (2021a), Kot et al. (2021b).

2.2.9. Kroczycka Cave, Kroczyce, Zawiercie district; 50.35142° N; 19.32279° E

The cave is situated among the so-called Kroczyce Rocks, on the slope of Popielowa Hill. It takes the form of a large chamber approximately 20 × 20 m and about 1.5–3 m high (Fig. 6**:6)**, access to which is via a small opening, hardly visible from afar. The site was discovered in 1936 when calcite miners found around 40 human skeletons inside the cave. Apart from the human remains, the surface survey undertaken in the same year revealed numerous Bronze Age and Migration Period artefacts within the top part of the sediments (Mycielska and Rook, 1966; Wrzesiński, 2006; Jędrysik and Wagner, 2015). Due to the lack of direct indications, the chronology of the human bones remained uncertain (Godłowski, 1995).

Unfortunately, while most archaeological finds from the 1930 s are stored in the Archaeological Museum in Cracow, the anthropological collection was lost. The human remains analysed in the present study were found during the recent surface survey made inside the cave by this paper's authors. The archaeological assemblages from Kroczycka Cave are kept in the Archaeological Museum in Cracow and in the Institute of Archaeology, Nicolaus Copernicus University in Toruń.

In Kroczycka Cave, a fragmentarily preserved bronze brooch type A.158, variant Ojców 1 or 3, was discovered. This artefact is broadly dated to phases C1b–D, although, bearing in mind the context of other finds from the Cracow Upland, it is highly probable that it corresponds with phase D1 (Jakubczyk, 2014, 146). Worth noting also is a clay bead type TM.480, dated to phases B2–D, as well as a likely carnelian bead type TM 504 from phases C3–D and a bone bead type TM.494, which may be dated to phases C1–D (Tempelmann-Maczyńska, 1985, 87–89; Wrzesiński, 2006; Jędrysik and Wagner, 2015, 44). Interestingly, the cave also yielded the upper stone of a rotary quern, made of sandstone, with a lower surface covered with small hollows. Its connection with phases C1–D is very likely (Jędrysik and Wagner, 2015). Other Roman/Migration Period finds come from the area in front of the entrance to the cave, such as a bronze strap-end, dated to phases C3–D (likely D1) and a glass bead type TM.161 from the C2–D phases (Jędrysik and Wagner, 2015, 45).

3. Methods

3.1. Osteoarchaeology

Osteoarchaeological examination has been performed on 224 bones identified as human remains (**Supplement**). Other analyses conducted on definite human remains are indicated in Table 2. In the cases of Koziarnia Cave, Łokietka Cave, Boczne Rockshelter near Łokietka Cave, Ciemna Cave, Upper Cave at Ogrojec and Boczne Rockshelter at Ogrojec, the human remains come from old fieldwork and were stored together with animal remains. In those cases the studied assemblages consist of human remains distinguished from the animal remains. Only a single human bone from Koziarnia Cave was found during recent fieldwork conducted by one of the co-authors in 2017 (Kot et al., 2021) in the backfill of the old fieldwork. In the cases of Zbójecka Cave and Kroczycka Cave, the human remains were found by the authors on the current surface of the cave sediments during surveying. Only the human remains from Żarska Cave come from recent fieldwork conducted by two of the co-authors (Wojenka et al., 2016).

The osteoarchaeological analysis of the human bone assemblages from all the nine caves in question was performed according to traditional morphological methods with special modifications for commingled burials (Brothwell, 1981; Scheuer and Black, 2000; White and Folkens, 2005). The human remains discovered included only non-articulated bones. Due to the nature of these collections, the analysis focused on identifying the most likely number of individuals (MLNI), which was estimated by pair-matching between commingled homologous elements based on their gross morphology (Adams and Konigsberg, 2004). Morphological analysis of the bone material from each of the analysed sites and the preservation of the skeletal remains are presented as part of the **supplementary materials** (see **Supplement**).

3.2. Preliminary genetic analyses

Ancient DNA (aDNA) analyses were conducted in order to determine the sex of the studied individuals. The in-depth aDNA results will be provided in a separate paper. Analyses were performed on 20 bone samples from Łokietka Cave (n = 11), Koziarnia Cave (n = 5), Żarska Cave (n = 2) and Boczne Rockshelter near Łokietka Cave (n = 2) (Table 2).

Genetic analyses were performed at the Laboratory of Paleogenetics

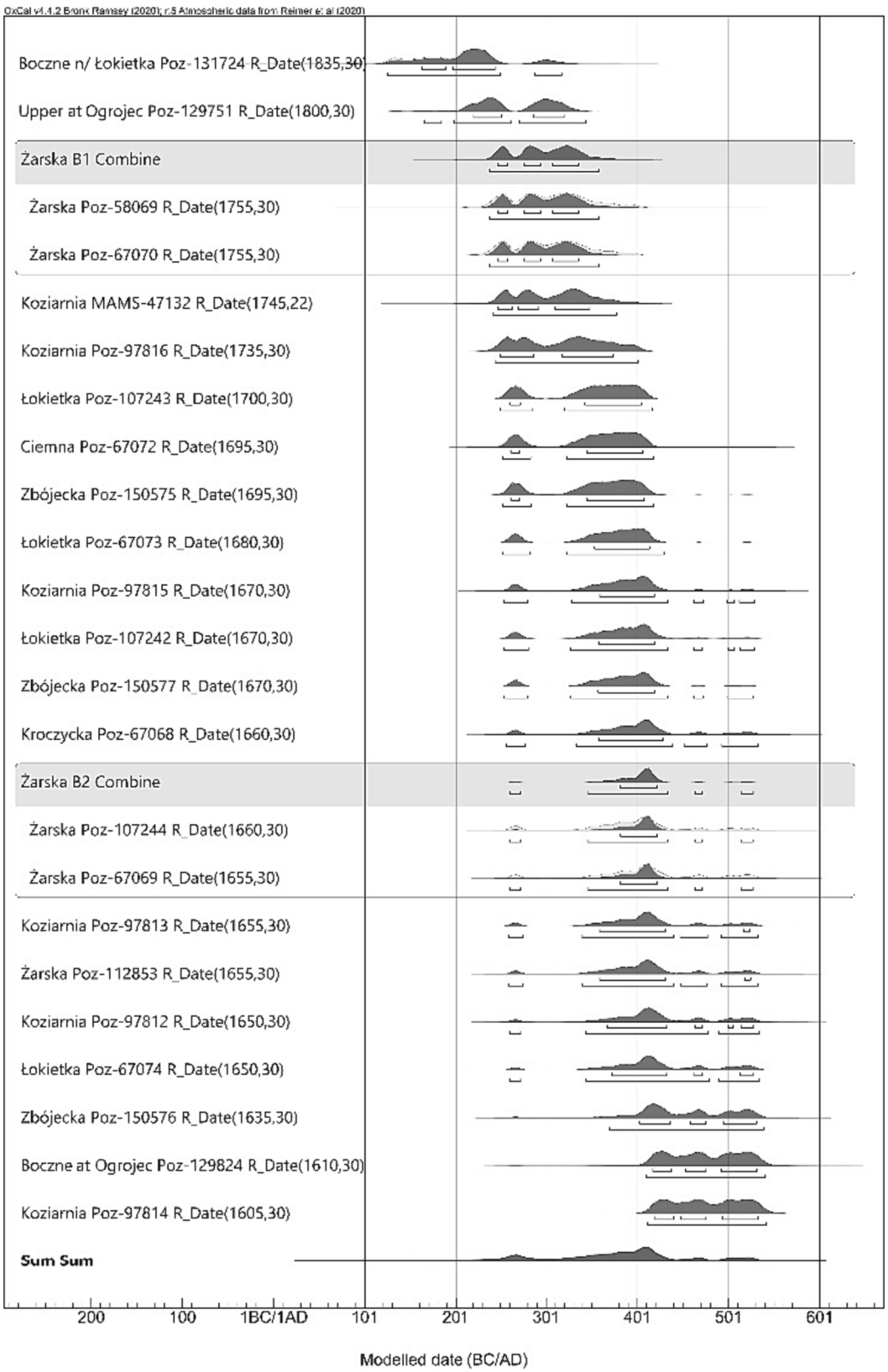

Fig. 7. Calibrated dates of bone samples analysed in the present study. Radiocarbon dates were calibrated using OxCal v.4.4.2; r:5 Atmospheric data from IntCal20 (Reimer et al., 2020).

Table 2
Summarised results of all analyses conducted on the chosen human remains.

		C14			C/N						Sr		aDNA				
Site	anatomical attribution	Lab no.	14C BP	1-sigma	Sample	%C	%N	(C/N)at	d15N	d13C	Sample	result	Sample	#reads mapped to ref sequence	#reads mapped without duplication	% endogenous DNA	Molecular sex determination
Żarska Cave	lower M1; adultus, ♀ [?]	Poz-112853	1655	30	RF-15	48.8	17.9	3.18	9.2	−19.7	RF-15	0.711917					
Żarska Cave	lumbar vertebra; infans II	Poz-67069	1655	30	B2/838	48.1	17.7	3.17	8.84	−20.03							
Żarska Cave	elbow; infans II	Poz-107244	1660	30	G38 (A1/525)	45.3	16.5	3.2	8.61	−19.79			PL010	2,059,783	17,996	0.87 %	
Żarska Cave		Poz-58069	1755	30	B1/863	43.7	15.9	3.2									
Żarska Cave	lumbar vertebra; infans I	Poz-67070	1755	30	B1/863	46.7	17.3	3.15	8.69	−20.11							
Żarska Cave	humerus; infans II				G39 (B1/814)	47.11	15.67	3.51	8.4	−19.62			PL011	2,513,084	109,681	4.36 %	male
Koziarnia Cave	humerus; distal epiphysis, right, adultus	Poz-97814	1605	30	KOZ1	48.2	17.6	3.2	8.25	−19.57			PL012	1,845,968	581	0.03 %	
Koziarnia Cave	femur; diaphysis, right, adultus	Poz-97812	1650	30	KOZ2	50.7	18.6	3.18	7.88	−19.94			PL013	2,133,076	107	0.01 %	
Koziarnia Cave	humerus; adultus	Poz-97813	1655	30	KOZ3	46.3	18.2	3.19	8.88	−19.48			PL014	2,221,986	137	0.01 %	
Koziarnia Cave	tibia; diaphysis, adultus	Poz-97815	1670	30	KOZ4	48.9	17.9	3.2	7.01	−20.07			PL015	1,409,359	4610	0.33 %	
Koziarnia Cave	calotte; adultus	Poz-97816	1735	30	KOZ6	50.9	18.7	3.17	12.45	−19.01			PL016	2,529,215	11,384	0.45 %	
Koziarnia Cave	lower I; infans I (<1 y.o.)	MAMS-47132	1745	22	KOZ_B67	38.1	13.9	3.2									
Łokietka Cave	lower M1; maturus,♂	Poz-67073	1680	30	JŁ_1	45.2	16.4	3.21	8.2	−18.8	RF-05	0.712362	PL005	2,308,952	22,655	0.98 %	
Łokietka Cave	lower M1; iuvenis	Poz-67074	1650	30	JŁ_2	44.4	16.5	3.13	8.88	−20.76	RF-02	0.709746	PL006	795,750	5722	0.72 %	
Łokietka Cave	femur; left, adultus	Poz-107242	1670	30	G40	48.8	17.7	3.22	9.17	−16.07			PL007	141,194,627	10,711,017	7.59 %	male
Łokietka Cave	femur; left, adultus				G41	47.13	15.19	3.62	8.88	−20.76			PL008	1,426,238	76,029	5.33 %	
Łokietka Cave	femur; left, adultus	Poz-107243	1700	30	G42	42.8	15.5	3.22	9.07	−19.65			PL009	731,050	12,545	1.72 %	
Łokietka Cave	lower C; adultus				RF-19/ II-7727						RF-19	0.711625					
Łokietka Cave	frontal bone; male, right,				PMA1								PL017	1,955,900	358	0.02 %	

(*continued on next page*)

Table 2 (*continued*)

Site	anatomical attribution	C14			C/N						Sr		aDNA				
		Lab no.	14C BP	1-sigma	Sample	%C	%N	(C/N)at	d15N	d13C	Sample	result	Sample	#reads mapped to ref sequence	#reads mapped without duplication	% endogenous DNA	Molecular sex determination
	adultus (27–35)																
Łokietka Cave	II metatarsal; right, adultus				PMA2								PL018	2,073,435	10,737	0.52 %	
Łokietka Cave	humerus; shaft, left, adultus				PMA25								PL022	2,135,066	168	0,01 %	
Łokietka Cave	humerus; shaft, right, adultus				PMA26								PL023	1,315,204	1382	0,11 %	
Łokietka Cave	ulna; shaft, right, adultus				PMA29								PL024	1,304,071	9864	0,76 %	
Łokietka Cave	fibula; shaft, right, adultus				PMA30								PL025	3,355,425	94,363	2,81 %	male
Boczne Rockshelter near Łokietka Cave	temporal bone; right, adultus, ♀ [?]	Poz-131724	1835	30	SkJL_01 (PMA23)	48	17,6	3,17					PL021	203,989,568	21,254,146	10,42 %	female
Boczne Rockshelter near Łokietka Cave	parietal bone; frontal angle, left, adultus				PMA9								PL019	1,151,373	264	0,02 %	
Zbójecka Cave	clavicle; left, adultus	Poz-150575	1695	30	ZB3_X2021												
Zbójecka Cave	humerus; right, infans I (ca 1 y.o.)	Poz-150576	1635	30	ZB2_X2021												
Zbójecka Cave	metatarsus; infans I (<5. y.o.)	Poz-150577	1670	30	ZB6_X2021												
Ciemna Cave	mandible; adultus/maturus (30–40 years)	Poz-67072	1695	30	JC_2	43,6	15,7	3,23	9,9	−19,3							
Upper Cave at Ogrojec	tibia; shaft, left, adultus	Poz-129751	1800	30	Gorna_PMA48_H	49,7	18,1	3,19	8,4	−20							
Boczne Rockshelter at Ogrojec	rib; shaft, adultus	Poz-129824	1610	30	SPG_PMA41_H	53,2	20	3,11	8,7	−19,9							
Kroczycka Cave	lumbar vertebra; adultus/maturus	Poz-67068	1660	30	JK_1	48,7	16,5	3,44	8,14	−19,56							

and Conservation Genetics, Centre of New Technologies at the University of Warsaw in the laboratory dedicated to work with aDNA. All recommendations for working with aDNA which minimize the possibility of contamination with modern DNA were followed. Prior to DNA extraction, bone fragments were washed with double-distilled water and UV-irradiated (245 nm) for 10 min from each side. After the outer surface of bone was removed, around 50–100 mg of bone powder was drilled using a Dremel tool and DNA extracted following the protocol proposed by Rohland et al. (2018). DNA extracts were treated with USER enzyme mix to minimize the impact of cytosine-to-uracil post-mortem deamination. Double-indexed sequencing libraries were obtained using the modified protocol of Meyer and Kircher (2010). DNA preservation in the samples was assessed by shallow shotgun sequencing on the NextSeq Illumina platform (MidOutput, 150 cycles, paired-end). The library with the highest amount of endogenous DNA and complexity was used for deeper shotgun sequencing on the NovaSeq Illumina platform (100 cycles, single-end). Sequencing reads were demultiplexed using bcl2fastq, adapter sequences were removed using AdapterRemoval v. 2 (Lindgreen, 2012) and the reads were mapped against the hs37d5 human reference genome using bwa 0.7.17 (Li and Durbin, 2010). Samtools (Li et al., 2009) were used for quality filtering and duplication removal. The sex of the analysed samples was determined by calculating the ratio of sequence reads aligning to X and Y chromosomes (Skoglund et al., 2013).

3.3. Radiocarbon dating

In total, 21 human individuals found in the nine studied caves were radiocarbon dated. The dates were obtained from 17 bones and six teeth. Samples were dated with the AMS radiocarbon method in the Poznań Radiocarbon Laboratory (Poland; 20 datings) and the Max Planck Institute for the Science of Human History (single dating). One sample was dated twice (Table 2).

The dated fraction was collagen extracted using the Longin method (Longin, 1971), supplemented by removing humic substances in NaOH and purified by ultrafiltration (Bronk Ramsey et al., 2004; Brock et al., 2010). All samples met the quality criteria, as indicated by carbon and nitrogen percentages ranging from 38.1 to 53.2 % and 13.9–20.0 % respectively, and atomic C/N ratios between 3.11 and 3.44 (Table 2).

Calibrated radiocarbon dates (AD/BC) were obtained based on the IntCal 20 radiocarbon calibration curve (Reimer et al., 2020) and OxCal 4.4.2 calibration software (Bronk Ramsey, 2009).

3.4. Strontium isotope analysis

Sr isotope analyses included human tooth enamel from three samples obtained from Łokietka Cave (M1—*maturus*, male; M1—*iuvenis*, sex undefined; C—*adultus*, sex undefined) and one sample from Żarska Cave (M1—*adultus*, possibly female). The Sr isotope analyses were carried out at the Isotope Laboratory of Adam Mickiewicz University in Poznań, Poland. The procedure included the chemical separation of Sr and measurements of Sr isotope ratios. Before analysis, the mechanically isolated enamel was cleaned in an ultrasonic bath in ultrapure water to remove the sediment particles. Afterwards, approximately 10 mg of powdered enamel was treated sequentially with 0.1 ultrapure acetic acid (five times) to eliminate diagenetic Sr contamination, according to the procedure described by Dufour et al. (2007). Subsequently, the samples were dissolved on a hot plate (~100 °C overnight) in closed PFA vials using 1 N HNO_3. The powdered sediment sample (~50 mg) was dissolved on a hot plate (~100 °C, three days) in closed PFA vials using a mixture of concentrated hydrofluoric and nitric acid (4:1). The miniaturized chromatographic technique described by Pin et al. (1994) was applied for Sr separation. Some modifications in the column size and concentration of reagents were introduced by Dopieralska (2003). Strontium was loaded with a $TaCl_5$ activator on a single Re filament and analysed in dynamic collection mode on a Finnigan MAT 261 mass spectrometer. During this study, the NBS 987 Sr standard yielded $^{87}Sr/^{86}Sr = 0.710238 \pm 10$ (2σ mean on ten analyses). Total procedure blanks were less than 80 pg. The $^{87}Sr/^{86}Sr$ values were corrected to $^{86}Sr/^{88}Sr = 0.1194$. The Sr results for samples were normalized to a certified value of NIST-987 = 0.710240.

3.5. Carbon and nitrogen isotope analysis

Eighteen human bone samples found in seven caves were available for carbon and nitrogen stable isotope analysis. Collagen was extracted using the Longin method (Longin, 1971) either in the laboratory of the Department of Bioarchaeology, University of Warsaw or at the Poznań Radiocarbon Laboratory.

Samples were measured at one of two facilities: 1) the Department of Forest Ecology and Management, Swedish University of Agricultural Sciences (Sweden), using isotope ratio mass spectrometer Delta V (Thermo Fisher Scientific, Bremen, Germany) and the elemental analyser Flash EA 2000 (Thermo Fisher Scientific, Bremen, Germany), against international standards (IAEA-600, IAEA-CH-6, IAEA-N-2, USGS40 and USGS41); and 2) the Stable Isotope Laboratory, Goethe-Universität Frankfurt, Germany using the Flash Elemental Analyser 1112 (Thermo Fisher Scientific, Bremen, Germany) connected to the continuous flow inlet of a MAT 253 gas source mass spectrometer (Thermo Fisher Scientific, Bremen, Germany), along international standard materials USGS 24, IAEA-CH-7, IAEA-N1 and IAEA-N2. The external analytical precision was better than ± 0.2 ‰ for C isotopes and ± 0.3 ‰ for N isotopes. Sample quality was assessed based on collagen preservation, carbon and nitrogen content in the dry bone and the carbon to nitrogen ratio (Guiry and Szpak, 2021).

Individuals from the caves of the Cracow Upland were further compared to contemporary Central European animals of known dietary preferences (Hakenbeck et al., 2010; Halffman and Velemínský, 2015; Plecerová et al., 2020) and human populations of Central Europe dated to the Roman Iron Age and Migration Period and the Early Middle Ages (Hakenbeck et al., 2010; Reitsema and Kozłowski, 2013; Knipper et al., 2013; Halffman and Velemínský, 2015; Plecerová et al., 2020).

4. Results

4.1. Chronology

The majority of the calibrated radiocarbon dates for the analysed human bones fall in the range between the third and fifth centuries AD (19 dates from six caves; Fig. 7), although it cannot be excluded that the oldest sample (from Boczne Rockshelter near Łokietka) comes from the second century AD, while the two youngest samples (from Boczne Rockshelter at Ogrojec and Koziarnia Cave) come from the sixth century AD. The sum of probability distributions (displayed at the bottom of Fig. 7) shows that individuals of the population studied could be placed at any time during this period, although they were probably concentrated between ca 360 and 420 CE. The whole set of dates covers a time interval of 230–400 years (95.4 %) (calculated using the 'Span' command of Oxcal). For Koziarnia Cave, the site with the most numerous samples (six), the dates for the human remains cover almost the whole range studied. Conversely, dates from Łokietka Cave (five samples, including Boczne near Łokietka) come from the older part of the range, while in the 'at Ogrojec' sites, no sample coming from the middle part of the range was detected. However, the number of samples per individual site is low, so the differences indicated above cannot be regarded as significant.

During absolute ^{14}C dating of human bones, the possibility of reservoir effects, affecting the ^{14}C ages of individuals who fed themselves with food of aquatic origin (e.g., Cook et al., 2001; Olsen et al., 2010) must be considered. The share of water-derived food in the diet can be monitored by measuring ^{15}N and ^{13}C in collagen, mostly because the $^{15}N/^{14}N$ ratios of aquatic organisms are generally higher than those

of terrestrial organisms. Values of $\delta^{15}N$ determined in radiocarbon-dated bones generally fall between 7.0 and 9.2 ‰, which, according to regional studies (e.g., Reitsema et al., 2010; Goslar et al., 2017,; Makarowicz et al., 2021), is characteristic of humans exclusively relying on terrestrial food sources. Therefore, it can be concluded that the ^{14}C ages measured in the present study truly represent the dates of death for the individuals studied. Two possible exceptions are the ages of bone KOZ6 from Koziarnia Cave and SkJL-01 from Boczne near Łokietka Cave. In the first case, a $\delta^{15}N$ of 12.5 ‰ was measured, and in the second case, the nitrogen isotope has not yet been measured. Nevertheless, excluding the dates of these samples from consideration would not change the general chronology of the bones studied.

4.2. Osteoarchaeology

The commingled character of the finds obscures the interpretation of the finds' contexts. Most of the analysed sites contained remains of at least several individuals, although in three cases, the minimum number of individuals was established as one (Table 3, **Supplement**). The remains were disarticulated, forming commingled assemblages in various states of preservation. The calculated percent of skeleton preservation points towards 5–40 %, but the number of intact bones was low, with significant differences in the frequencies of cranial and postcranial fragments (Fig. 8, **Supplement**).

Due to the analysed remains' commingled character, sex and age-at-death determinations were available only on single diagnostic skeletal elements, making the assessments prone to error and less reliable than in the case of complete skeletons (White and Folkens, 2005; Cunha et al., 2009). All of the sites contained remains of adult individuals, but in the case of five (Żarska Cave, Koziarnia Cave, Łokietka Cave, Zbójecka Cave and Kroczycka Cave), subadult remains have also been identified. The ages of the subadults varied from young children to adolescents, with only some infant skeletal fragments (1–3 years old) found in Łokietka Cave and Zbójecka Cave. When the adults' age could be determined in more detail, the full range of ages from young adults to relatively advanced age was identified. It should be noted that, apart from one individual from Łokietka Cave, no remains of children under three years old have been identified.

The sex determination in adult individuals yielded similar numbers of elements characterized by male and female morphology. The relatively low number of observed pathological changes included primarily degenerative changes to vertebral bodies, and the assemblage characteristics do not allow conclusions to be reached at an individual or populational level. Detailed information on the osteoarchaeological analysis of the individuals is provided in the **Supplement**.

4.3. Genetic analyses

The content of endogenous DNA was very low in all samples (Tables 4 & 5). At the preliminary stage of the analyses sex determination could only be performed on four samples. Based on the ratio between X-chromosomal coverage and autosomal coverage, and using a number of sequences aligned to the Y chromosome compared to the total number of sequences aligned to both the X and Y chromosomes, it was determined that one individual was female (PL021) while three others were males (PL007, PL011 and PL025) (Tables 4 & 5). More detailed analyses are planned in future which require more extensive comparative studies.

Table 3
The minimum number of individuals (MLNI) identified in the analysed caves.

Site	Number of individuals	Adults	Subadults	Total number of bones
Żarska Cave	3	1	2	38
Koziarnia Cave	6	3	3	21
Łokietka Cave	8	5	3	133
Boczne Rockshelter near Łokietka Cave	1	1	0	8
Ciemna Cave	1	1	0	at least 51
Zbójecka Cave	3	1	2	3
Upper Cave at Ogrojec	1	1	0	7
Boczne Rockshelter at Ogrojec	2	2	0	7
Kroczycka Cave	3	2	1	5
TOTAL	**25**	**16**	**9**	**224**

4.4. Strontium isotopes

The human individuals deposited in the Łokietka and Żarska caves show a large variation in their tooth enamel $^{87}Sr/^{86}Sr$ values, from 0.7097 to 0.7124 (Table 6). This range also comprises Sr isotope signatures of faunal teeth from small rodents collected from the sediment infill in the caves.

4.5. Carbon and nitrogen isotopes

All 18 human samples met the quality criteria (for details, see Table 2). The samples express $\delta^{13}C$ values between −20.8 ‰ and −16.1 ‰, with a median of −19.7 ‰ (Table 7). The $\delta^{15}N$ values of human individuals varied between 7.0 ‰ and 12.5 ‰, with a median of 8.7 ‰ (Table 7).

5. Discussion

5.1. Roman and Migration Period human remains in the caves

The results obtained indicate that at least 25 individuals found at nine cave sites in the Cracow Upland were placed there during the Roman and Migration Periods. Due to the commingled character of the assemblages, the number of identified individuals must be treated as a minimum number of individuals. Even with such numbers, the results of our study show an unexpectedly intense phenomenon of human bones occurring in caves during the Roman and Migration Periods in the Cracow Upland. What is more, eight of those caves are located in the very restricted area of the Prądnik and Sąspów Valleys, in the heart of a dense concentration of caves in the karstic region of the Cracow Upland. The single remaining site, i.e., Kroczycka Cave, is located 50 km north in the central part of the region.

We may differentiate the two kinds of sites used. In two cases, human remains were found in shallow rockshelters. In seven cases, we are dealing with large caves. Interestingly, there is a definitive clustering of the rockshelters with nearby caves, as in the case of Łokietka Cave and a Rockshelter near Łokietka Cave and in the case of Upper Cave at Ogrojec and a Rockshelter near the Ogrojec Cave. Considering the above-mentioned possible scatter of dates, these two site clusters might indicate a continuity of the described phenomenon over time.

When it comes to caves, only the large-chambered sites, sometimes with long corridors that, for the most part, are entirely or almost entirely dark, yielded human bones. This certainly was not by chance, since the region abounds with hundreds of caves of different sizes and exposure to daylight. If we assume a likely relationship with particular mortuary practices (see below), it cannot be excluded that the selection of large caves resulted from the scope of the rituals, designed for large groups of people who congregated inside, which therefore suggest that these rituals were non-secret and non-private affairs (see Dowd, 2015).

Thanks to radiocarbon dating, the whole phenomenon can be placed within a long time span of 125–540 CE. However, it should be stressed that most individuals (n = 18) found at five sites can be dated to a very limited time span of 300–400 CE. Only two individuals from Upper Cave at Ogrojec and the Rockshelter near Łokietka Cave may potentially be associated with an earlier chronology (125–350 CE), whereas a single individual found in the Rockshelter near Ogrojec Cave produced a date of 413–542 CE (95.4 %). In the case of these three outliers, the dated human remains represent the only identified individuals found at these sites.

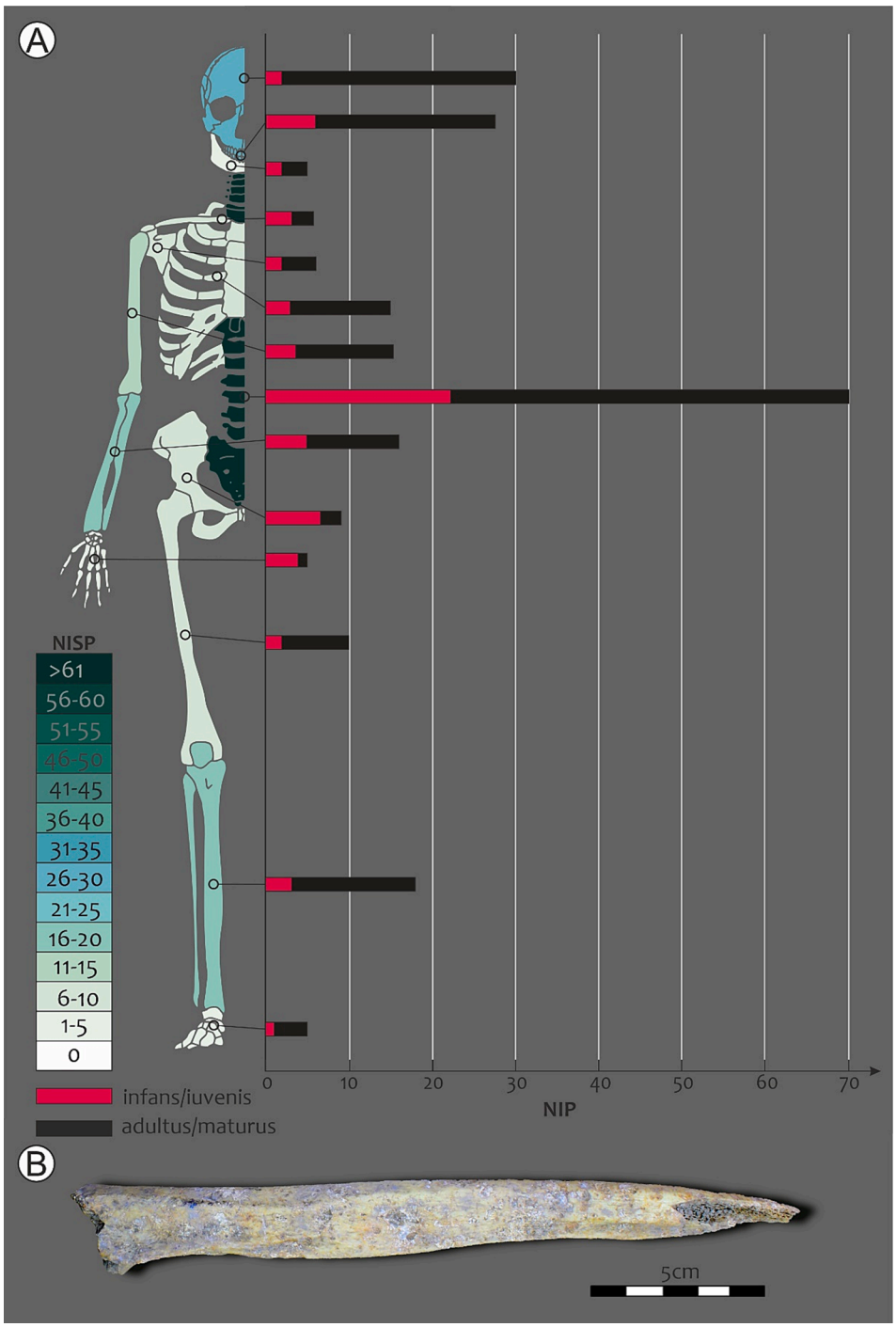

Fig. 8. A. Total number of identified specimens (NISP) within specific anatomical categories; B. Left ulnar diaphysis from Upper Cave at Ogrojec with gnaw marks.

Nevertheless, we may assume that this phenomenon was not restricted to these caves alone. Artefacts of a similar chronology have been noted so far in approximately 50 cave sites in the region (Table 1). In 16 of them, human remains were found, but they have not been dated. Some of these caves yielded artefacts that can be plausibly interpreted as grave furnishings, such as strap-ends, tendril brooches and combs (Godłowski, 1995; Dobrzańska, 2006).

Given that most of this material is derived from legacy excavations, the archaeological context of the finds is not clear. Human remains were found in the Holocene humus layers, which may contain settlement traces dating from the Mesolithic up to modern times (Rook, 1980). Due to relatively intense cave use throughout the millennia, the original stratigraphical context of the Roman and Migration Period activity has been destroyed. For this reason, we are dealing here with multiple disarticulated bones, which in most cases cannot be securely attributed to specific individuals. However, there are strong indications that in many cases, the presence of bones belonging to multiple individuals may be expected. Regarding the sites analysed in this study, the osteological analyses indicate the presence of multiple individuals in at least four caves, i.e., Koziarnia Cave, Łokietka Cave, Zbójecka Cave and Żarska Cave (Table 3). However, this is probably also the case for Kroczycka Cave, where approximately 40 individuals were said to have been found in the 1930 s (Mycielska and Rook, 1966). It should be noted that the assessment presented here errs on the side of caution. The original

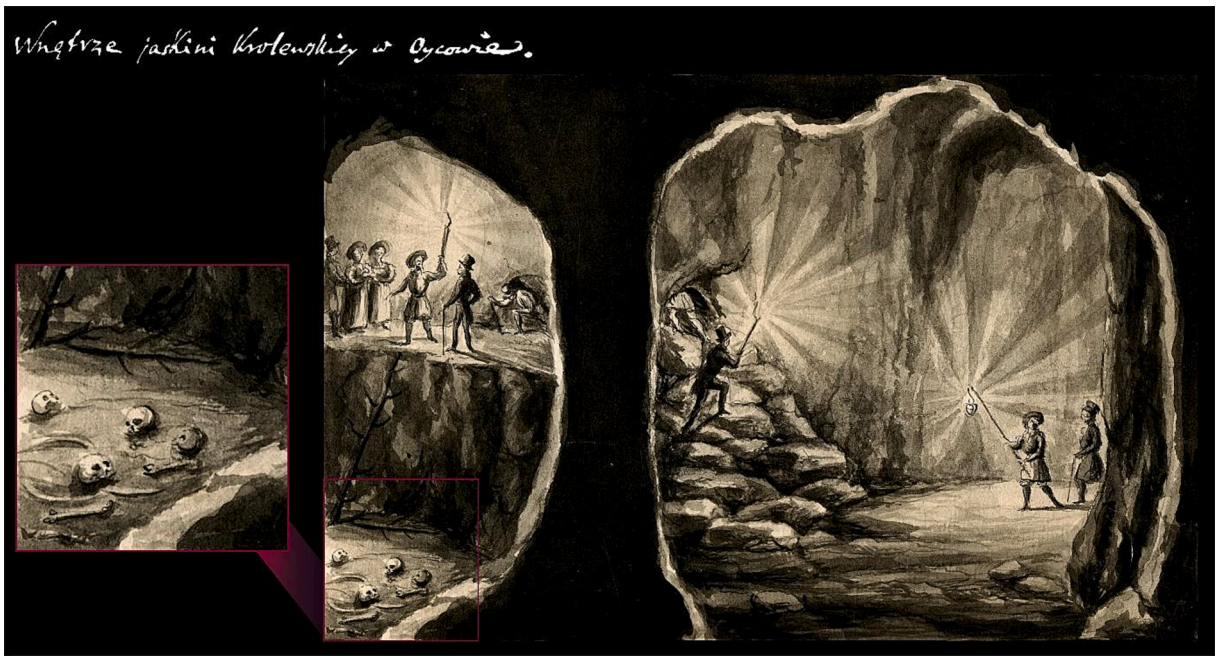

Fig. 9. A pencil drawing by T.B. Stachowicz (probably from 1835) depicting the interior of Łokietka Cave (formerly Królewska Cave) with numerous human remains lying on the cave floor. Courtesy of the Museum of the Lubomirski Princes, The Ossolinski National Institute, Wrocław.

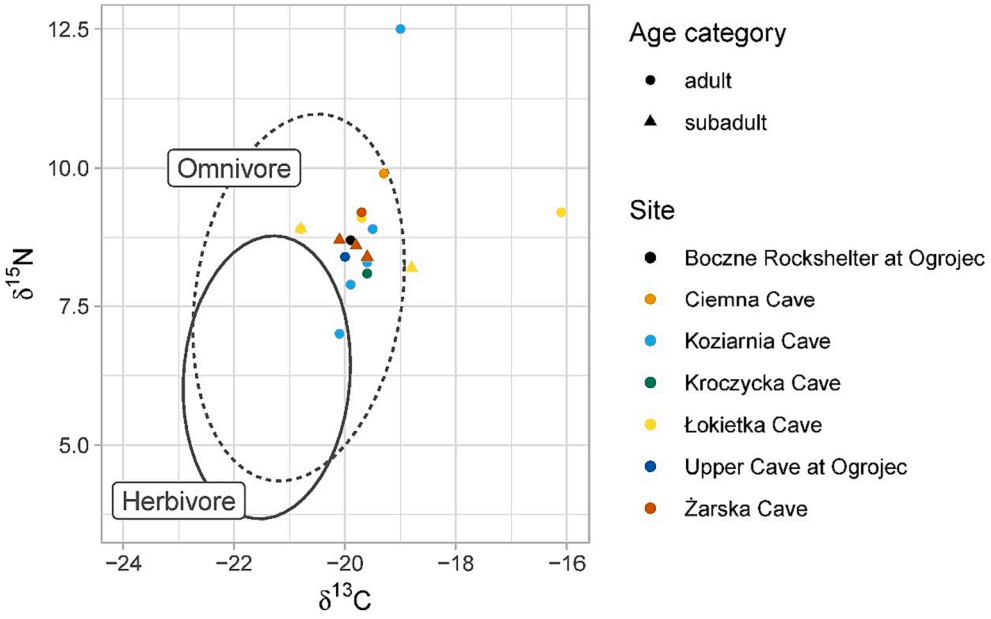

Fig. 10. Results of the carbon and nitrogen stable isotope analysis for human individuals found in the caves of the Cracow Upland and Central European animals, grouped according to their dietary preferences. Animal data after (Hakenbeck et al., 2010; Halffman and Velemínský, 2015; Plecerová et al., 2020).

number of individuals could be much higher. This possibility is strengthened by 19th-century iconography (Fig. 9) and the descriptions of some caves in the area, where large numbers of human bones, including skulls, were noted by visitors directly on the cave floor (e.g., Jastrzębowski, 1854).

The broad spectrum of the assessed sex and age at death of the analysed individuals is a noteworthy aspect of the assemblages presented here. Osteoarchaeological analyses accompanied, due to the commingled character of the assemblage, by aDNA analyses indicate that we are dealing here with individuals of both sexes representing newborns, children of different ages, youths and adults (Tables 2 & 3, **Supplement**). The results indicate that the phenomenon was restricted neither by age nor sex, but only further aDNA analyses might shed light on their possible familiar relationships.

The heterogeneity of the group is also evident in their diet. The obtained $\delta^{13}C$ values between −20.8 ‰ and −16.1 ‰ indicate a diet based on C_3 plants, with a single exception. Regarding the $\delta^{15}N$ values, compared to the animal data (Table 8, Fig. 10), these human individuals are enriched in heavier nitrogen isotopes relative to herbivores ($\Delta^{15}N_{human\text{-}cattle} = 3.0$ ‰; $\Delta^{15}N_{human\text{-}horse} = 2.5$ ‰; $\Delta^{15}N_{human\text{-}ovicaprid} = 1.9$ ‰) and opportunistic omnivores ($\Delta^{15}N_{human\text{-}chicken} = 0.4$ ‰; $\Delta^{15}N_{human\text{-}pig} = 1.4$ ‰), except for one dog ($\Delta^{15}N_{human\text{-}dog} = -0.3$ ‰). The comparison indicates that these human individuals regularly consumed animal proteins.

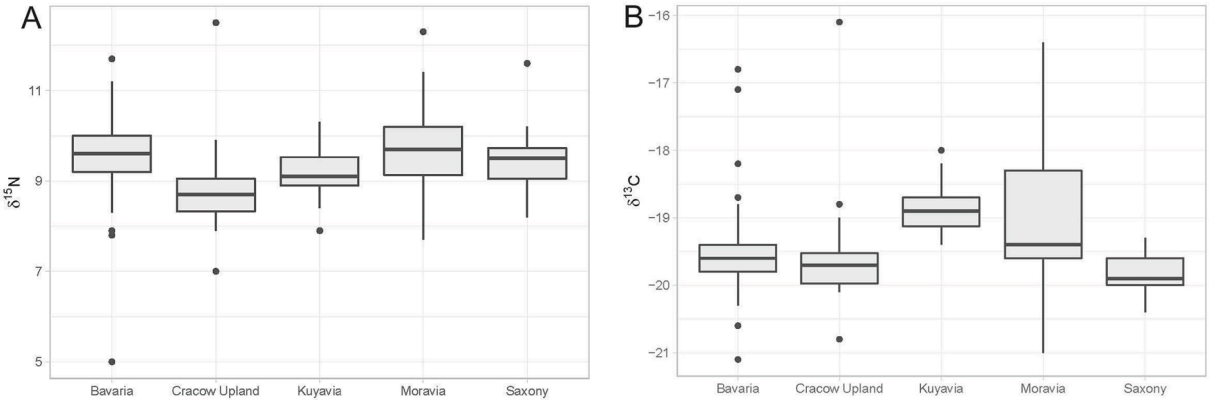

Fig. 11. Comparison between human populations living in Central Europe during the Roman and Migration Periods and the Early Middle Ages. .
Source: Hakenbeck et al., 2010; Reitsema and Kozłowski, 2013; Knipper et al., 2013

Table 4
Ratio between coverage of X chromosome and autosomal coverage.

	PL007	PL011	PL025	PL121
xCoverage	0.114027	0.00159862	0.00130819	0.49034
yCoverage	0.0250998	0.00034507	0.00026955	0.00096679
autCoverage	0.255485	0.00306584	0.00263078	0.528036
X/A	0.44631583	0.52142969	0.49726317	0.92861093
	Male	**Male**	**Male**	**Female**

The comparison with other Central European groups (Fig. 10) shows a statistically significant difference (Kruskal-Wallis test: $H = 83.76$, $df = 4$, $p < 0.001$). The post-hoc Mann-Whitney test (with Holm's correction for pairwise comparison) indicates differences in $\delta^{13}C$ values between the Cracow Upland and Kuyavia ($p < 0.001$) and Moravia ($p = 0.006$). In Kuyavia (Central Poland) and Moravia (eastern Czechia), millet consumption was found to be expressed in the isotopic composition of bone collagen (Reitsema and Kozłowski, 2013; Halffman and Velemínský, 2015). In the studied area, only a single individual from Łokietka Cave expresses high $\delta^{13}C$ values, typical of millet consumption (the $\delta^{15}N$ values remain moderate). The presence of such an outlier is not uncommon and has been attested, for example, in Bavaria (Hakenbeck et al., 2010). Occasionally, they are interpreted as migrants. However, studies of migration based on strontium isotopes conducted at Bavarian sites (Schweissing and Grupe, 2000) confirmed that a single individual from Altenerding (AED513) with a high $\delta^{13}C$ ratio was of local origin (Hakenbeck et al., 2010).

Additionally, a single individual expresses a very high $\delta^{15}N$ value (KOZ6, Fig. 11). Possible explanations include exceptionally high animal protein consumption, moderate consumption of animal proteins characterized by moderate carbon and high nitrogen stable isotope ratio values (e.g., freshwater fish) or physiological stress. The individuals studied had access to the local rivers and could potentially have supplemented their diet with freshwater fish. The final interpretation option is problematic. Physiological stress can elevate the nitrogen stable isotope ratio in rapidly secreted tissues, e.g., the bone of infants (e.g., Tsutaya and Yoneda, 2015) and pathological bone (Katzenberg and Lovell, 1999). In tissues with slower bone turnover, the signal of stress is usually lost between collagen secreted during 'normal' times (Nitsch et al., 2010, Walter et al., 2020). Sample KOZ6, a calotte from an adult human individual, bears no signs of pathological changes and, since it belonged to an adult individual, the bone turnover took a few years. Hence, it is doubtful that stress elevated the nitrogen isotope ratio.

Based on the representation of body parts and the limited evidence for postmortem manipulation, the remains do not appear to have been involved in extensive secondary mortuary rituals. The overwhelming majority of the analysed material did not show any intentional manipulation traces (only one small fragment of neurocranium from Koziarnia Cave exhibited signs of burning. See **Supplement**). The relatively low number of small bones (i.e., hand and foot bones, ribs) could indicate either postmortem disturbance of the remains or some collection problems in the case of historical excavations. The lack of intact crania and the deficiency of large bones would rather imply the former. Regarding the lack of archaeological context and the state of bone preservation, it is difficult to conclude whether the deceased were initially buried or only

Table 5
Number of reads mapping to Y-chromosome (Skoglund et al., 2013).

	PL007	PL011	PL025	PL121
X reads	240,899	3016	2485	976,888
Y reads	20,798	264	200	946
Ry(Y/X + Y)	0.07947359	0.0804878	0.0744879	0.00096744
CI	5.48E-07	4.4225E-05	5.0325E-05	1.94E-09
Ry − CI	0.07947304	0.08044358	0,07443757	0,00096744
Ry + CI	0.07947414	0.08053203	0.07453822	0.00096745
	Male	**Male**	**Male**	**Female**

Table 6
Sr isotope composition of human and animal enamel samples from infills of caves in the Cracow Upland and of a sample from alluvial sediments from the Saspówka valley.

Sample No.	Site, locality	Sample material	Teeth type	$^{87}Sr/^{86}Sr$
RF-02	Łokietka Cave	human enamel	first molar	0.709746 ± 6
RF-05	Łokietka Cave	human enamel	first molar	0.712362 ± 10
RF-19	Łokietka Cave	human enamel	canine	0.711625 ± 10
RF-15	Żarska Cave	human enamel	first molar	0.711917 ± 14
RF-09	Żarska Cave	animal enamel rodent	incisor	0.712406 ± 11
RF-10	Żarska Cave	animal enamel/rodent	incisor	0.712466 ± 11
RF-12	Żarska Cave	animal enamel/rodent	incisor	0.712441 ± 15
RF-13	Tunel Wielki Cave	animal enamel/rodent	incisor	0.710652 ± 10
RF-14	Łokietek Cave	animal enamel/rodent	incisor	0.711624 ± 9
RF-18	Bramka Rockshelter	alluvial sediment	–	0,717644 ± 10

Table 7
Summary results of the carbon and nitrogen stable isotope analysis of the individuals found in the caves. N- number of samples. Note: reported is the age of tissue formation.

Site	Age	N	$\delta^{13}C$			$\delta^{15}N$		
			min	median	max	min	median	max
Koziarnia Cave	adult	5	−20.1	−19.6	−19.0	7.0	8.3	12.5
Łokietka Cave	subadult	2	−20.8		−18.8	8.2		8.9
Łokietka Cave	adult	3	−20.8	−19.7	−16.1	8.9	9.1	9.2
Ciemna Cave	adult	1		−19.3			9.9	
Upper Cave at Ogrojec	adult	1		−20.0			8.4	
Boczne Rockshelter at Ogrojec	adult	1		−19.9			8.7	
Żarska Cave	subadult	4	−20.1	−19.7	−19.6	8.4	8.7	9.2
Kroczycka Cave	adult	1		−19.6			8.1	

Table 8
Summary of the carbon and nitrogen stable isotope data for theselected Central European animals dated to the Migration Period and the Early Middle Ages. .

Animal	N	$\delta^{13}C$			$\delta^{15}N$		
		min	median	max	min	median	max
Cattle	36	–22,8	–21,4	–19,4	3,9	5,7	8,0
Chicken	8	–20,9	–20,1	–19,7	7,2	8,3	11,6
Dog	9	–21,9	–20,0	–17,1	6,3	9,0	11,2
Horse	26	–22,8	–22,1	–18,8	4,0	6,2	9,6
Ovicaprid	31	–22,2	–21,2	–19,8	5,0	6,8	11,2
Pig	38	–22,0	–21,1	–19,0	3,9	7,3	9,5

Source: Hakenbeck et al., 2010; Halffman and Velemínský, 2015; Plecerová et al., 2020

deposited on top of the cave floor.

On the other hand, a non-interment deposition of the dead may be to some extent confirmed by the presence of gnaw marks made by larger animals observed on one of the bones from Upper Cave at Ogrojec (left ulnar diaphysis, see also Fig. 8**: B** and description in **Supplement**). Although the rest of the human remains from this site, possibly originating from the same individual, do not show any traces of animal activity, the marks suggest that at least one fragment was exposed or readily available, which would be unusual for a typical inhumation. However, the other remains in question bear no signs of gnawing.

The low number of small bone fragments combined with the equal representation of the larger elements (i.e., femurs and pelvic girdle) also precludes the possibility of burial practices such as secondary collective deposition in the form of an ossuary placed as a singular event or accumulation over a period of time. Such ossuaries commonly include only larger bones, e.g., skulls or femurs—bones that are easily recognized as human. The presence of skull fragments and the occurrence of some large bones (e.g., tibias and humeri) seem to preclude intentional ritualistic behaviour, e.g., leaving the dead exposed above the ground to facilitate exhumation for secondary, perhaps proper, cremation burial (see below). Notably, all the aforementioned doubts may have arisen from more recent history of these caves; since at least the 19th century (but possibly much earlier; see Kurzej, 2018), human bones may have been taken from caves as souvenirs by visitors (R.P. 1854; *cf.* Grabowski, 1830; Jastrzębowski, 1854), which undoubtedly greatly affects our interpretations.

Eight out of the nine sites in question provided archaeological finds related to the third to mid-fifth centuries AD. Although the lack of archaeological context does not allow any firm conclusions to be drawn, given the radiocarbon dates it does appear that these artefacts are contemporary with the studied human remains, and, hypothetically, that they represent the same activity in these caves. Notably, most of the finds from the aforementioned caves, excluding a quernstone and possibly the storage vessels (*cf.* Przybyła et al, 2010), appear in funeral contexts. This is especially true for the necklace beads (e.g., in Ciemna Cave and Łokietka Cave). Apart from beads, the assemblages in question consist of both clothing elements (brooches, belt fittings), as well as toiletries (combs), riding gear and weaponry (spurs and possibly spearheads) and silver denarii. All of these sites yielded a remarkable amount of wheel-turned pottery typical for this time and area, representing both small smooth tablewares adorned with polished ornament and hard-coarse vessels including storage containers with collar-shaped rims. Also, handmade pottery is present.

The relationship between the human remains and the multiple artefacts of the same chronology found in these caves cannot be proven. However, one should stress that many of them represent clothing and personal adornments that may be considered grave goods (Fig. 5**,** Table 9). Additionally, a clay rattle found in Koziarnia Cave was recently radiocarbon dated to 252–401AD (Kontny et al., 2021), suggesting a relationship between the human remains and at least some of the artefacts. On the other hand, some caves yielded a number of storage vessels of the Krausengefässe type, which are absent from cemeteries, although they were noted in unusual ritual graves occurring at open settlements (Przybyła et al., 2010).

5.2. Conflict or plague victims, ritual human offerings or evidence for funeral practices?

In investigating the presence of human remains within caves, it is important to consider various potential explanations for this phenomenon. First, the data obtained reveal some indications of atypical (deviant) burial practices like unusual types of burial (body inhumation instead of more typical cremation) and the location (cave burial instead of an open cemetery). Second, the absence of deliberate selection based on sex or age groups for the interred individuals or for the presence of selected separated body parts offers substantial evidence against a hypothesis involving ritualistic activities. Finally, our observations demonstrate a consistent pattern of complete human skeletal remains deposited within the caves. Notably, the scattering of these skeletal remains appears to be a consequence of exploratory activities conducted in the modern era. Combined, these findings suggest that, though an atypical character to the described burials is apparent, the intention and reasoning behind it are hard to ascertain.

Could the caves be a place of shelter and the human remains reflect the victims of aggression? Or maybe the bones belong to the victims of violent conflict with no time for proper burial? Such events occurring in the past are rarely demonstated by direct archaeological traces, although the first situation is believed to have happened in Andritsa Cave, Argolid, Greece, where more than 40 people were probably sealed in the cave in the sixth to mid-seventh century (Kormazopoulu & Hatzilarou, 2005). In our cases, however, such explanations seem unlikely due to the number of caves, their heterogeneity, the long radiocarbon time span of the individuals studied and the lack of signs of trauma that could be attributed as the direct cause of death.

Did they die from an infectious disease, and due to the fear of contagion were their corpses placed in caves? Such an interpretation was made for the human remains of Visigothic age discovered in Cantabrian caves (Hierro Gárate, 2008; 2022) although this is debated (Gutiérrez González, 2010; Gutiérrez Cuenca & Hierro Gárate, 2012;

Table 9
Types of LR/EMP artefacts found at each of the studied cave sites.

	Fibulae	Necklace beads	Belt fittings	Combs	Weaponry	Spurs	Coins	Bucket frames	Spindle-whorls	Wheel-turned pottery	Hand-made pottery
Żarska Cave			+							+	+
Koziarnia Cave		+	+		+		+		+	+	+
Łokietka Cave		+							+	+	+**
Boczne Rockshelter near Łokietka Cave		+			?						
Ciemna Cave Upper Cave at Ogrojec	+	+	+	+		+	+	+*	+	+	+**
Boczne Rockshelter at Ogrojec					?						
Zbójecka Cave	+				+				+		
Kroczycka Cave	+	+	+					+*	+*	+	+**

* In front of the cave entrance.
** Storage containers.

Arias et al., 2019). In our case, the available data do not allow us to answer this question. Acute infectious diseases do not usually leave any traces on bones.

Were they individuals or groups excluded from the community, resulting in a deviant form of burial? Due to the lack of restriction of sex and age, it appears unlikely. No recognizable morphological features of the bones have been found to indicate impairment or disability that might have resulted in social ostracism. There is no evidence of intentional ritual manipulation visible through osteological analysis, and the lack of a clear archaeological context means this issue of possible social exclusion cannot be resolved. On the other hand, the almost complete (see Fig. 8**:B**) lack of carnivore gnaw marks precludes the possibility that the bones were dragged into the caves by animals.

All the arguments mentioned above indicate that we are dealing here with unusual funeral practices (presumably combined with mortuary rituals) conducted in the caves. Despite the lack of direct indications (see above), we lean towards a hypothesis that the bones in question are mostly or entirely (*cf.* Fig. 8) the remnants of burials, later destroyed by more or less recent human or animal activities (displacement of human remains as a result of creating burrows) that took place in these caves.

The remaining question is the origin of such unique practices within the regional settlement area.

5.3. Locals or newcomers?

One of the main questions is whether these remains represent local Przeworsk cultural groups of people with unique cave ritual practices or migrants who brought their nonlocal funeral practices to the Cracow Upland.

The vast majority of the artefacts found at the studied sites regularly occur in the *milieu* of the Przeworsk culture and may be seen as rather average in terms of wealth. There are, however, some elite finds, such as a copper-alloy strap-end from Ciemna Cave (Ogrojec), decorated in the Sösdala-Untersiebenbrunn style (Madyda-Legutko and Wojenka, 2020). Similar finds are very rare in European Barbaricum. As of today, only six specimens are known from the territory of the Przeworsk culture, concentrated along the southern reaches of this culture—on the left banks of the Vistula, Prosna and Pilica rivers. Similar finds appeared also outside this culture—in the famous hoard from Zamość, linked with the Gothic circle, in Lithuania and northern Slovakia (worth noting is the find from Kaplnka Cave at Nemce), in eastern Germany and in the middle Danube area (Beograd). The strap-ends in question probably coexisted with oval-framed buckles with prongs ending in depictions of animal heads. Importantly, their use is demonstrated both for male and female costumes, as well as for horse harnesses (Madyda-Legutko, 2011, 97–100, map 24). It is necessary to look more closely at the incised decoration in the form of hatched triangles. Such ornamentation does not appear on similar strap-ends from Germany and Lithuania, while it was noted on the other metal objects decorated in the Sösdala-Untersiebenbrunn style, discovered in the Carpathian Basin, western Ukraine and in eastern Poland (Bitner-Wróblewska et al., 2020, 230, Fig. 231A). In this respect, the other finds from Ciemna Cave (Main Chamber) should be recalled—miniature axe-pendants of types 3 and 5, according to Kokowski. Although both types incidentally appear in the *milieu* of the Przeworsk culture, it is type 5 which seems to be predominantly linked with the Carpathian Basin (Kokowski, 1998, 101, Figs. 7, 9).

To answer the question of whether we are dealing with locals or newcomers, special attention must be paid first to the radiocarbon chronology of the analysed remains, which clearly speaks in favour of a long chronology for these cave funeral customs (230–400 years). This evidence corresponds both with the archaeological finds from the caves, which generally relate to phase C1a, and the overall impression that only societies very familiar with the surrounding landscape would be able to know the location of caves such as the ones discussed in this paper—predominantly sites with large chambers or corridors, but hidden by their small entrances (Fig. 12). There are, however, some arguments that slightly distort this picture.

First, although cremation was widely practised by Przeworsk cultural groups throughout the whole Roman Period, i.e. from the turn of the eras until ca AD 375 (Godłowski, 1985; Zagórska-Telega, 2019), single inhumation burials incidentally appeared within cemeteries already in the later Pre-Roman Period (Niewęgłowski, 1981), as well as both the Early Roman (Zagórska-Telega et al., 2014) and, especially, the Late Roman and Early Migration Periods (phases C3–D1 covering the fourth and the beginning of the fifth centuries AD) (Mączyńska, 1992; Bohr, 2015; Mączyńska and Jakubczyk, 2017; Machajewski and Schuster, 2020, 339–343).

Second, mention needs to be made of the results of the strontium isotope composition analysis. Following the suggestion of Price et al. (2002) that the best way to characterize the local strontium signature is to measure the archaeological teeth of small mammal species that lived locally, it could be said that the individual (RF-02), having the most unradiogenic Sr signature of 0.7097, is of nonlocal origin, while three individuals with strong radiogenic $^{87}Sr/^{86}Sr$ values were born locally. However, this conclusion does not seem to be correct if we consider the entire Sr isotope system of the local environment (Figs. 3 & 13).

Note that the $^{87}Sr/^{86}Sr$ values of human enamel reflect a weighted average of Sr obtained from all the food and drink ingested in childhood when the enamel was formed (e.g., Burton and Hahn, 2016). The primary sources of Sr for terrestrial food and drink are the geological substrate and drinking water, respectively (Capo et al., 1998). Hence, due to the mixing of Sr coming from both reservoirs, the resulting Sr isotope composition of human enamel presents a $^{87}Sr/^{86}Sr$ ratio which represents the difference between the composition of the geological substrate and the drinking water (e.g., Szczepanek et al., 2018; Lengfelder et al., 2019; Toncala et al., 2020) and is usually very close to that

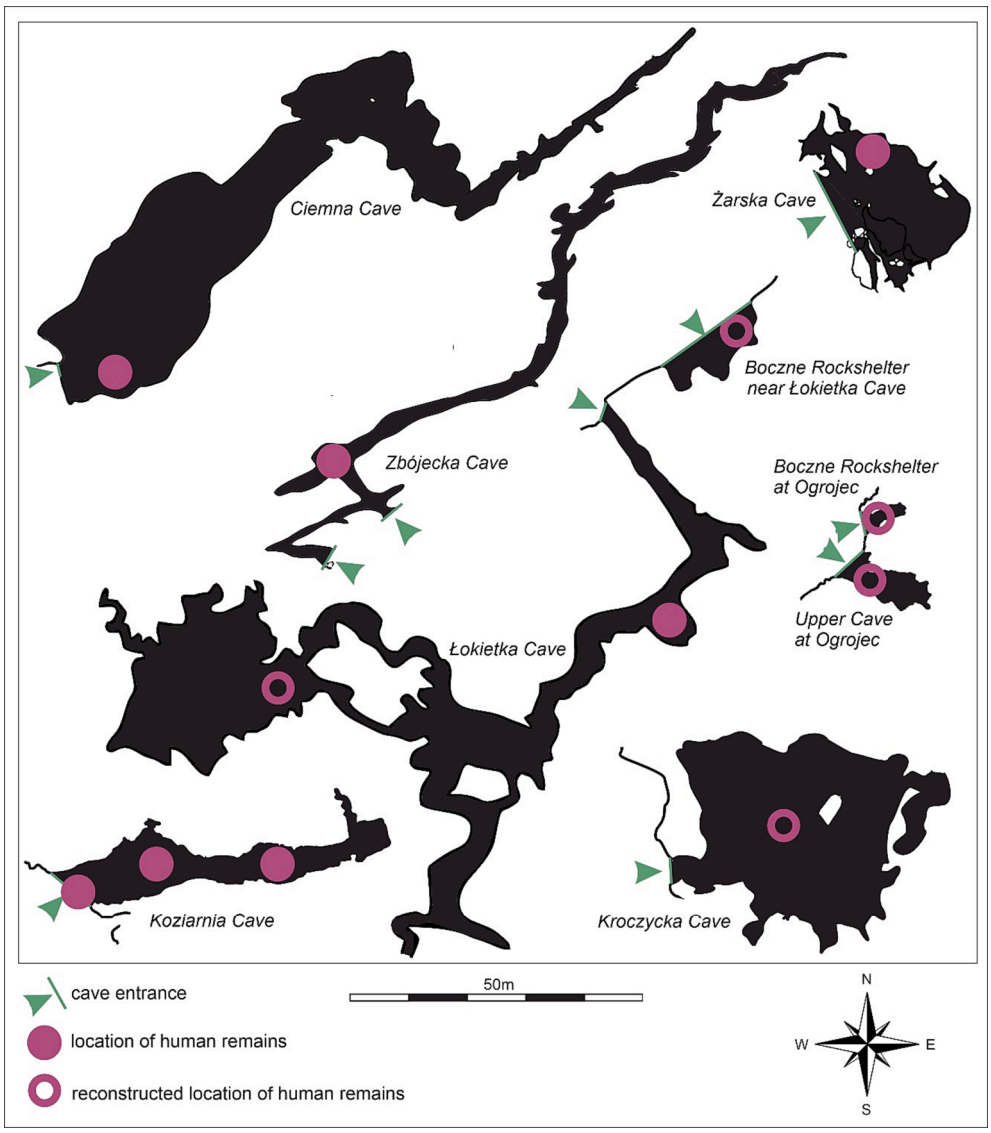

Fig. 12. Outlines of the nine cave sites where human remains from the Roman and Early Migration Periods were discovered.

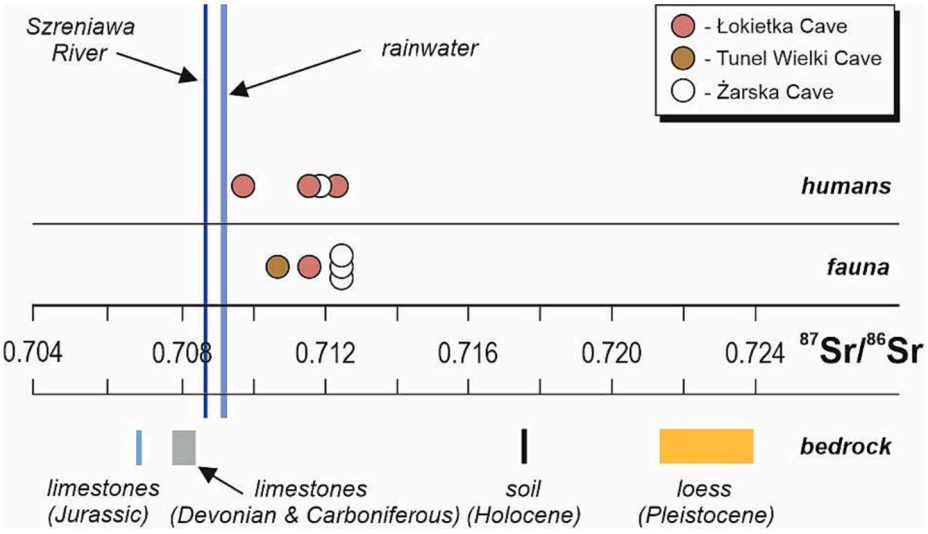

Fig. 13. Ranges of $^{87}Sr/^{86}Sr$ ratios in human and animal enamel from the investigated caves, along with values for local geological bedrock, rainwater and riverine water in the study area.

of the water (e.g., Zieliński et al., 2016; Schroeder et al., 2019; Łuczkiewicz et al., 2022).

Although no Sr isotope measurements of bedrock and water samples have yet been carried out in the area adjacent to the investigated caves, the Sr isotope composition of several elements in the local natural environment can be estimated. Sr isotope signatures of the Palaeozoic and Jurassic carbonates can be adopted from the Sr isotope secular curve for marine precipitates (McArthur et al., 2020). Hence, it can be assumed that the Devonian and Carboniferous limestones are characterized by an unradiogenic composition with signatures between 0.7077 and 0.7083. The Middle and Upper Jurassic limestones are undoubtedly even less radiogenic, with $^{87}Sr/^{86}Sr$ ratios of approximately 0.7068 to 0.7070 (Zieliński et al., 2021). In contrast to the Palaeozoic and Mesozoic substrate rocks, sediments of the Pleistocene cover exhibit a radiogenic composition. The Vistulian loess deposits exposed north-east of Cracow show $^{87}Sr/^{86}Sr$ values between 0.7214 and 0.7239 (Szczepanek et al., 2018; Schroeder et al., 2019). However, their radiogenic Sr signatures do not have any visible influence on dissolved Sr in local riverine water. The Szreniawa River, which flows parallel to the Prądnik River approximately 20 km to the east and drains bedrock similar to that of the study area, has a water-soluble $^{87}Sr/^{86}Sr$ value of 0.7086 (Schroeder et al., 2019). Because Jurassic and/or Palaeozoic limestones constitute the main aquifer levels in the study area, it seems very likely that riverine waters in the valleys adjacent to the investigated caves also yield low $^{87}Sr/^{86}Sr$ ratios, lower than those of rainwater and close to the Sr signatures of the carbonate substrate.

Taking this into account we should address the importance of rodents in determining the local Sr baseline. Several studies revealed that the usage of fauna to derive baselines can lead to incorrect conclusions (e.g., Maurer et al., 2012; Burton and Hahn, 2016; Szczepanek et al., 2018; Lengfelder et al., 2019; Britton et al., 2020; Holt et al., 2021). The bones and enamel of small rodents do not provide, in our opinion, a robust measure of local Sr isotope ratios for distinguishing migrants. This is because the diet of these animals differs significantly from that of humans. Rodents rarely drink water; instead their diet relies on carbohydrate metabolism to supply water (e.g., Frank, 1988), i.e. they obtain water metabolically from their food (seeds and insects). This is most likely the reason why the Sr isotope signatures of the investigated rodents are significantly more radiogenic than the rainwater and surface waters in the study area (Fig. 13).

Considering all these issues, it appears more likely that one individual from Łokietka Cave with an unradiogenic Sr signature of 0.7097 is of local origin, while the other two from the same site and the individual from Żarska Cave are nonlocals (Fig. 13). This is because the most significant elements in the local environment, having the largest impact on the composition of surface waters, are unradiogenic Jurassic limestones. Recent archaeological provenance studies conducted in the Cracow Upland in areas with a very similar structure and composition of the bedrock, where radiogenic loess deposits form only a relatively thin cover on the surface, revealed that the local range of $^{87}Sr/^{86}Sr$ values for humans is very close to that of the surface water, and ranges from 0.7095 to 0.7110 (Szczepanek et al., 2018; Schroeder et al., 2019; Linderholm et al., 2020). The Sr isotope signatures of the three individuals investigated ($^{87}Sr/^{86}Sr$ = 0.7116–0.7124) are characteristic of local populations in areas with a predominance of strongly radiogenic rocks or sediments in the shallow substrate (for example, in Poland, see Pospieszny and Belka, 2015; Price and Frei, 2015; Belka et al., 2019). Among the closest-lying regions that meet this condition are northern and central Poland (Zieliński et al., 2021), north-eastern Germany, south-western Sweden, northern Ukraine (west of Kyiv), and several smaller areas, such as the Holy Cross Mountains, the Sudetes and the Harz Mountains.

Worth noting here is that only a juvenile individual originated from the vicinity of the caves, while the remaining three people were nonlocal adults. Although it is difficult to conclude on the basis of such a small dataset, it may recalled that—based on the settlement data, i.e. a decrease in the settlement density of the Przeworsk culture in its northern range and its clear concentration in the south (see Mączyńska, 1999)—from phase C1 onwards, the *milieu* of the Przeworsk culture, specifically in its southern range, was the subject of internal colonization (Zagórska-Telega, 2019), and hence it is theoretically possible that this is reflected by our Sr isotope readings.

The genesis of cave burial customs remains an open question. However, it shall be emphasized that, while the earlier group of radiocarbon dates may correspond with the period of the Marcomannic Wars (AD 166–180, see Friesinger et al., 1994; Fischer and van Ackeren, 2012; Erdrich et al., 2020), the more recent remains correlate with another wartime and migrative epoch—the Migration Period (Bursche et al., 2020). In the case of the younger group of human cave remains, the hypothesis of Mączyńska (1992), on how turbulent times could inspire and provoke some unusual and unique ritual practices, should be considered. Moreover, in both cases, migrations could raise the heterogeneity of groups, diversifying and intensifying the symbolic sphere.

Finally, particular attention should be drawn to the material culture elements from the caves. In most cases, they are of local origin, but single artefacts could indicate some foreign affinities. Apart from the caves discussed here, this is also the case for Wisielca (Pod Oknem) Cave at Kroczyce, where numerous artefacts of 'eastern' origin were discovered (Dymowski, 2007; Rudnicki and Sobczyk, 2013). The foreign ancestry of teeth from Wisielca Cave was recently suggested based on strontium analyses (Rudnicki, 2017), but since no dataset was provided, we were unable to compare our results. It is conceivable that the influx of such elements is connected with what is called a post-Chernyakhov horizon (Tejral, 1992), a phenomenon associated with migrations and cultural changes after the Hunnic invasion (including funeral customs, see, e.g., the Carpathian Basin and the southern Przeworsk culture; inhumation graves also appeared in the *Niemberg* group (Schmidt, 1964)). To conclude, it is difficult to be more specific about the scale of these possible changes in the Cracow Upland, but without excluding some external influences, we believe that the principal context in which the cave burial customs appeared was local (Tejral, 2000), although not exclusively so.

5.4. *The meaning of caves in the Late Roman and Early Migration Periods*

Caves have been used for funerary purposes almost since the dawn of time, with the view being that they served as final resting places in many periods and cultures. In much previous theoretical and methodological research on caves, the focus has been on their potentially prominent supernatural significance. The concept of a cave as a sacred place may have developed from the idea that these places belonged to a subterranean realm distinct from the world of the living (Whitehouse, 1992; Ustinova, 2009; Orschiedt, 2012; Moyes, 2014; Tomkins, 2014; Dowd, 2015; Silvestri et al., 2019). According to some theoretical approaches, caves may have been linked to the cyclical concept of life and death, and in a figurative sense, cave entrances could have been perceived as vaginal symbols (Dowd, 2015). For some periods in the past, they were only seemingly unanimated places—on the contrary, they *interacted* with people, becoming what was recently described as *vibrant places* (Prijatelj and Skeates, 2019). Finally, the caves can be seen as liminal sites, between above ground and below, between inside and outside, and, importantly, between the sacred and the profane (Büster et al., 2019).

Unfortunately, due to the lack of written records, we cannot determine the role of caves and rockshelters for the inhabitants of the Cracow Upland in the Roman and Migration Periods. There are, however, grounds for thinking that they might have been perceived as supernatural places, as they were for the inhabitants of Scandinavia some centuries (?) later. This may be demonstrated by the old Germanic beliefs gathered in the Early Middle Ages into the *Poetic Edda* (Edda, 1936), where caves are seen as mysterious and closely related to the realm of death. In the best known Edda's poem *Völuspá* (the prophecy of Völva),

which is considered the richest source for examining Nordic beliefs, we read of *Gnipahellir*, a cave guarded by a fierce hound, *Garm*, that barks at the entrance to the world of the dead—Hel (*Völuspá*, stanza 44, 49, 58; see Edda, 1936). Placing this narration in the context of *Ragnarök* may indicate that caves were associated with death and catastrophic events (Bergsvik, 2018). It is difficult to say whether the inhabitants of the Cracow Upland shared this or held similar views on caves, although it is worth noting that, according to both archaeological and written sources, the Przeworsk culture was associated with Germanic entities (Kolendo, 1981). The perception of caves as supernatural places among Germanic societies may also be later seen in the Visigothic kingdom of Toledo, where numerous human bones found in caves produced radiocarbon dates spanning the seventh and eighth centuries (Arias et al., 2018). As proven by archaeological examination results, some of the individuals were accompanied by charred grains, among them wheat *Triticum vulgare* (Luís Marino, 2014). In light of the early medieval penance books, charred grains on the corpses of the deceased may be regarded in the context of pagan customs forbidden by officials (Gutiérrez Cuenca et al., 2017). In this respect, it must be noted that in Łokietka Cave, in the same layer and place where the human bones were found, several charred plant remains were also discovered. Two of them, belonging to pea *Pisum sativum* and common wheat *Triticum aestivum,* were radiocarbon dated to 401–544 calAD and 255–420 calAD, respectively (95.4 % probability). It is not certain whether they were related contextually to the human bones. Worth noting, however, is the apotropaic meaning of some grains or seeds within funeral rituals (see Kurasiński et al., 2018).

6. Conclusions

The results show surprisingly intensive use of caves for funeral practices during the Roman and Early Migration Periods in the studied region. Regarding the identification of at least 25 individuals found in nine cave sites, the Cracow Upland can be compared only with the British Isles and Spain (although it differs in terms of the spatial distribution of samples) and seems to have no close parallels in the Central European *milieu*. This may be, however, deceptive. In our opinion, the outcomes of our analyses may pave the way for further studies of this phenomenon in Central Europe, especially in areas which formed part of the 'Germanic world' during the Roman and Migration Periods. It is highly conceivable that the above-described cave funeral practices may be set in a much broader context (*cf.* Bárta, 1955; Soják, 2005).

We would like to stress the importance of detailed multidisciplinary analyses of Holocene cave sediments in this context. Although often found within mixed Holocene contexts, human remains discovered in cave sediments can be an extremely valuable source of information. However, neither the surrounding archaeological artefacts nor a lack of artefacts should be the basis for determining their chronological affiliation. An excellent example of such assertions can be found in Zbójecka Cave, where multiple human remains were noted there already in the 19th century (Römer, 1883), accompanied by clearly Late Roman Period artefacts. Out of five dated human bones, two related to the late Bronze Age/Early Iron Age (Kot et al., 2021). Thus, only direct radiocarbon dating of human remains may provide the starting point for discussing the chronology of cave funeral practices.

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CRediT authorship contribution statement

Michał Wojenka: Conceptualization, Funding acquisition, Investigation, Visualization, Supervision, Validation, Writing – original draft, Writing – review & editing. **Bartosz Kontny:** Formal analysis, Writing – original draft, Writing – review & editing. **Marzena Przybyła:** Formal analysis, Writing – original draft, Writing – review & editing. **Anita Szczepanek:** Formal analysis, Writing – original draft, Writing – review & editing. **Elżbieta Jaskulska:** Formal analysis, Writing – review & editing. **Zdzislaw Belka:** Formal analysis, Visualization, Writing – original draft, Writing – review & editing. **Rafał Fetner:** Formal analysis, Visualization, Writing – original draft, Writing – review & editing. **Tomasz Goslar:** Formal analysis, Visualization, Writing – original draft, Writing – review & editing. **Grzegorz Czajka:** Formal analysis, Writing – review & editing. **Danijela Popović:** Formal analysis, Writing – original draft, Writing – review & editing. **Mateusz Baca:** Formal analysis. **Jarosław Wilczyński:** Data curation, Writing – review & editing. **Małgorzata Kot:** Conceptualization, Funding acquisition, Investigation, Supervision, Validation, Project administration, Visualization, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A. Supplementary material

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Further reading

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