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RESEARCH ARTICLE

Geographic origin and social status of the Gallic warriors from Ribemont-sur-Ancre (France) studied through isotope systematics of bone remains

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Abstract

Ribemont-sur-Ancre, France, is the biggest excavated human skeletal assemblage of Northern Gaul. It is interpreted as a post-battle deposit constructed to celebrate war. However, the chronology of the site, its organization and the origin of the buried warriors are still poorly understood. These problems are studied by a multi-proxy approach, based on radiocarbon dating, stable and radiogenic isotope analysis of bone remains from three structures within the site. A total of 47 human and 12 animal bone samples were analyzed for their oxygen isotope composition of bone bioapatite ($\delta^{18}\text{O}_p$), carbon and nitrogen isotope compositions of bone collagen ($\delta^{13}\text{C}_{\text{coll}}$ and $\delta^{15}\text{N}_{\text{coll}}$). Subsamples of 17 bone collagen and 20 bone samples were selected for radiocarbon dating and strontium isotope analysis ($^{87}\text{Sr}/^{86}\text{Sr}$), respectively. All samples show preservation from diagenesis, although $^{87}\text{Sr}/^{86}\text{Sr}$ contribution from the burial environment cannot be excluded. Therefore, the strontium isotope data are included in the study but are not used in the interpretation of the results. Homogeneous radiocarbon dates of human remains are observed, whereas later dates are obtained for some animal remains, highlighting the continuous use of the monument decades after the conflict. Human individuals have homogeneous $\delta^{18}\text{O}_p$ values, which are consistent with independent numismatic analyses and lead us to propose the Maine region as a potential geographic origin. Heterogeneities of $\delta^{13}\text{C}_{\text{coll}}$ and $\delta^{15}\text{N}_{\text{coll}}$ values are highlighted between individuals from different structures and are attributed to preferential access to animal protein and different social statuses among the buried warriors.

KEYWORDS

bones, diet, Iron Age, migration, stable isotopes

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1 | INTRODUCTION

Warfare, which is recorded since the Early Holocene (Lahr et al., 2016), displays the human condition in extreme situations. It has pushed societies to collaborate and innovate, but also led to acts of cruelty and vandalism. It is observed on prehistorical sites such as Talheim (Germany, Wahl & Trautmann, 2012) and is depicted in historical records, such as the chronicles of the conquest of Gilgamesh in 2700 BCE (Bauer, 2007) or the History of the Peloponnesian War by Thucydides (Vth century BCE).

Violence, massacres, and inter-tribal warfare are attested in Europe during the Iron Age by numerous archaeological sites, such as Alken Enge (Denmark, Holst et al., 2018), Maiden Castle Hillfort (England, Redfern, 2011) or La Hoya (Spain, Quesada-Sanz, 2015). During the Later Iron Age, the European territory was occupied by the Gauls, whose belligerent nature was recognized by all as depicted by Aristotle (n.d., Politics, IV, 1324b). Gallic society was composed of households and extended families, gathered in larger groups described by Caesar (n.d., *Comentarii de Bello Gallico*) as *pagi*, which occupied a politically and geographically coherent territory (Fichtl, 2004; Rose & Fernández-Götz, 2019). Each *pagi* had its own army and operated separately during military operations (Brunaux, 2005). Inter-tribal relationships, which were cultivated through continuous warfare, ranged from domination to alliance and clientelism (Brunaux, 2005; Fichtl, 2004). Because of the oral transmission of culture among the Gauls, no records of these confrontations have been found, and the only archaeological evidence of inter-tribal warfare are post-war deposits and ceremonial monuments (Fernández-Götz & Roymans, 2017). The Picardie region, North of France, is where these post-war monuments were first excavated in the years 1970–1980, with the emblematic one of Gournay-sur-Aronde (Brunaux et al., 1980; Rose, 2020) and the sanctuary of Ribemont-sur-Ancre. However, there are still many questions about the internal organization of these monuments and the conflicts that led to their construction.

1.1 | The Ribemont-sur-Ancre archaeological site

The Ribemont-sur-Ancre archaeological monument (49°57'53.4"N, 2°33'13.3"E) is built on the western slope of the Ancre river, 20 km northeast from the city of Amiens (Figure 1a). It is the biggest excavated human skeletal assemblage in Northern Gallic archaeology to date (Ricard, 2014; Rose, 2020) with ~23,000 human bone remains belonging to an estimated Minimal Number of Individuals (MNI) of 508 and ~10,000 iron components from weapons, harnesses and chariots (Brunaux et al., 1999). These objects, dated from the IIIrd century BCE, bear marks of their use in battle (Lejars, 1998). All human individuals are identified as men, which were mostly young and tall (Ricard, 2014). No crania were discovered, and numerous cervical vertebrae bear osteological evidence of beheading (Brunaux, 2018; Ricard, 2014), which is part of the Gauls' ritual treatment of dead enemies as attested by Diodorus Siculus (n.d., Historical

Library, V, 29, 4). Some bones bear marks of weapon impact or post-mortem dismemberment (Brunaux, 2018). The monument is interpreted as a post-battle deposit, dedicated to war, erected after a huge conflict between two or several populations (Brunaux et al., 1999; Ricard, 2014; Rose, 2020). Precise descriptions and interpretations of Ribemont-sur-Ancre can be found in Brunaux et al. (1999), Ricard (2014), Fercoq du Leslay (2017) and Rose (2020). However, there is still no consensus about the internal organization of the archaeological site, its chronology, the location of the confrontation and the origins of the warriors who took part in it (Brunaux et al., 1999; Ricard, 2014; Rose, 2020). These debates, which are presented in Appendix S1, mostly revolve around three specific deposit structures found within the site (Figure 1b, Figure S1).

The first one has been historically called “ossuary” and is comprised in a quadrangular enclosure located on the northern part of the site. The ossuary is a ritual pit under the form of a cubic bone frame of 1.65 m by side, made of limb bones from humans (~2000) and horses (~100), and filled in its center by bone ashes and fragments. The estimated MNI is 179. All bones are stratigraphically associated with the La Tène period. It was probably one of four similar ossuaries constructed in each corner of the quadrangular enclosure during the IIIrd century BCE (Rose, 2020).

East of the quadrangular enclosure, the second structure, interpreted as a “mass grave”, is a high concentrated deposit of weapons (~500) and human remains (~13,000). It is widespread on at least 35 m² and up to 40 cm deep. The computed MNI of 114 is probably an underestimation as the feature was heavily disturbed by the construction of a Gallo-Roman portico. Human skeletons are intact for the most part, and bones retain extensive anatomical connection (Ricard, 2014). Pedologic and paleoparasitological studies suggest a single deposit of the corpses, which were left to decay in the structure (Thiol, 2002). It is very similar to the archaeological deposit of Moeuvres c. 50 km to the Northeast (Salomon, 1913).

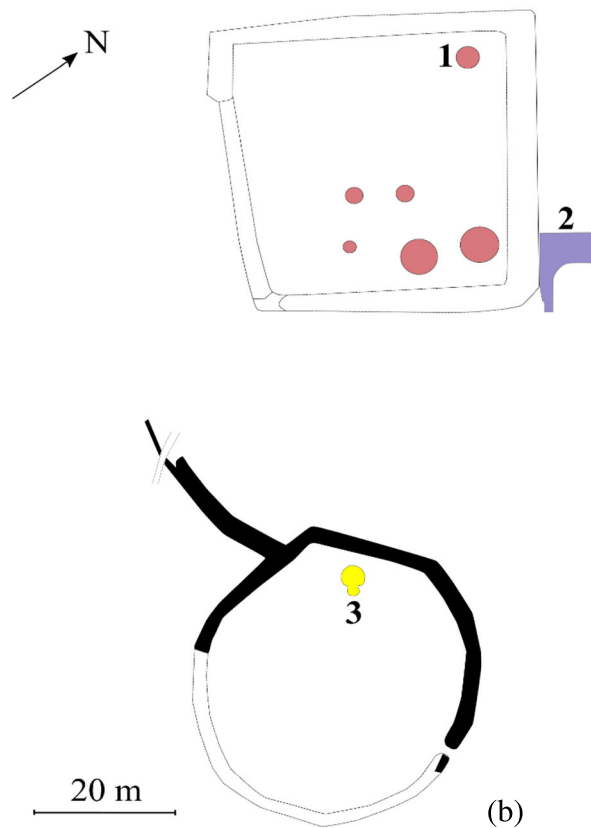
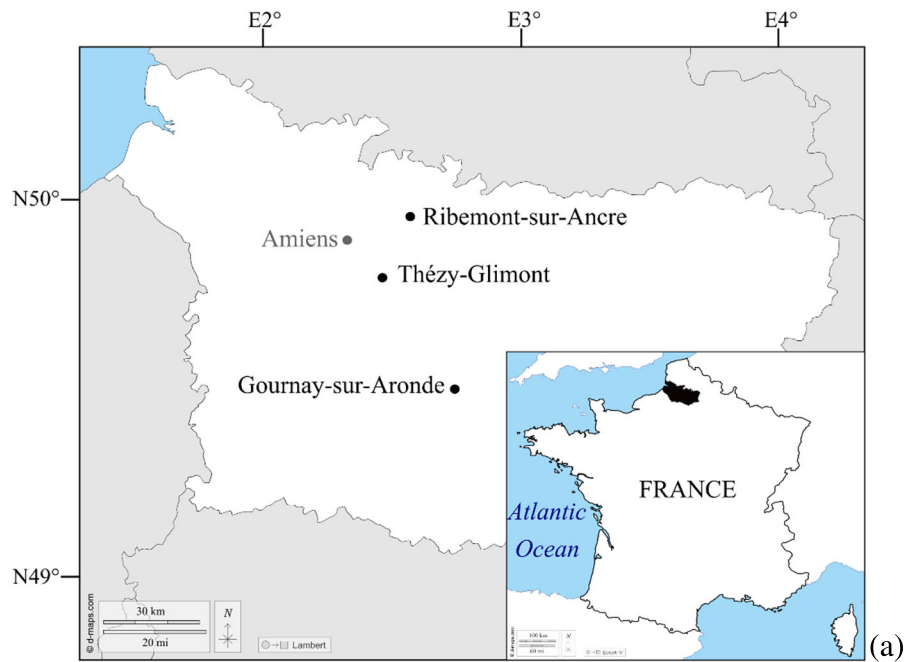
Finally, south of the site, the third structure is a “circular enclosure”, which contains, in its northern part, five pits in which a total of 391 human bones belonging to an estimated MNI of 30, associated with ceramics and animal bones, were excavated. Human bones bear marks of violence with documented extensive trauma (Ricard, 2014), whereas weathering and gnawing marks suggest exposure to the open air for between a decade to a year before the bones were collected for interment (Rose, 2020).

This paper seeks to further understanding of the site of Ribemont-sur-Ancre through radiocarbon dating, radiogenic and stable isotope analysis of the osteological material from these three structures.

1.2 | Radiogenic and stable isotope analysis of archaeological bone remains

Bioarchaeology techniques such as isotopic compositions of human and animal remains are frequently used to understand funerary and warfare archaeological sites, such as Eulau and Tollense Valley

FIGURE 1 (a) Geographic map of France with a focus on the Picardie region and location of the archaeological sites of Ribemont-sur-Ancre, Thézy-Glimont and Gournay-sur-Aronde. The datum used for latitude and longitude is WGS84. (b) General map of the Ribemont-sur-Ancre archaeological site with the three structures considered in the study: (1) the ossuary within the quadrangular enclosure, (2) the mass grave and (3) the circular enclosure. Other bone frame structures are represented as red circles. After Ricard (2014). [Colour figure can be viewed at wileyonlinelibrary.com]



(Germany, Haak et al., 2008; Price et al., 2019); Musselburgh (Scotland, Moore et al., 2020), Potočani (Croatia, McClure et al., 2020) or CA-YOL-117 (California, Eerkens et al., 2014).

Geographic origin of human populations can be studied using the radiogenic strontium ($^{87}\text{Sr}/^{86}\text{Sr}$) and stable oxygen ($\delta^{18}\text{O}$) isotope

compositions of bone remains. There is a direct link between an individual's $^{87}\text{Sr}/^{86}\text{Sr}$ signature and their geographic origin as strontium isotope ratios are affected by very low isotopic fractionations during transfer processes at low temperature and biologic absorption (Faure & Mensing, 2005; Price et al., 1994, 2002). Baselines of the

$^{87}\text{Sr}/^{86}\text{Sr}$ ratio available to biological organisms, called bioavailable strontium, have been generated through *in situ* sampling in different regions (e.g., Bataille et al., 2012; Evans et al., 2010) and allow mobility to be studied at a fine scale.

The oxygen isotope composition ($\delta^{18}\text{O}$) of mineralized tissues from mammals comes from food and drinking water (Kohn, 1996; Longinelli, 1984; Luz et al., 1984). Humans, as omnivores with moderate water turnover, have an oxygen isotope signature mainly imprinted by the $\delta^{18}\text{O}$ value of drinking water, which, during pre-industrial times, is assumed to come from local sources derived from local meteoric waters (Darling, 2006; Daux et al., 2005). Therefore, the $\delta^{18}\text{O}$ of bioapatite measured in human bone remains reflects the local meteoric water consumed during their adult life, whereas childhood can be studied using the $\delta^{18}\text{O}$ of bioapatite from tooth enamel (Clauzel et al., 2020).

Information about dietary practices can be acquired through carbon ($\delta^{13}\text{C}$) and nitrogen ($\delta^{15}\text{N}$) stable isotope analysis of bone collagen, as both systems are inherited from food (DeNiro & Schoeninger, 1983; Hare et al., 1991). The $\delta^{13}\text{C}$ value of bone collagen discriminates between a C_3 and a C_4 -plant diet or the consumption of marine products (Schoeninger & DeNiro, 1984). The $\delta^{15}\text{N}$ value of bone collagen indicates trophic-level due to an isotopic enrichment from prey to consumer comprised between +2‰ and +6‰ (DeNiro & Epstein, 1981; O'Connell et al., 2012; Schwarcz & Schoeninger, 1991). It is also a marine consumption indicator (Schoeninger & DeNiro, 1984), as higher $\delta^{15}\text{N}$ values are measured in marine organisms due to longer trophic chains in the ocean (Tykot, 2004).

2 | MATERIALS AND METHODS

A total of 59 samples were collected from bone remains of 47 humans and 12 animals from the three structures with respectively 19 human and 6 horse samples from the ossuary, 18 human samples from the mass grave (where animals are absent), 10 human and 6 animal samples from the circular enclosure. Bone samples of approximately 2 g were acquired using a toothless diamond saw blade fitted to a Dremel™ drill. For all individuals, we ensured to sample the same bone element, and on the same location within the bone, to avoid collecting the same individual twice. Specifically, right femur epiphysis was sampled for humans, right tibia epiphysis was sampled for horses from the ossuary and limb bone was sampled for animals from the circular enclosure. Human remains were treated with dignity and respect (Squires et al., 2019) and care was taken to keep destruction to a minimum, in the presence and in accordance with the curators of the Ribemont-sur-Ancre Conservation Center. All remaining material will be returned to permit future analysis while avoiding new sampling. All 59 bone samples were analyzed for their $\delta^{18}\text{O}$ value of bioapatite phosphate groups, $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values of bone collagen, whereas subsamples of 17 bone collagen and 20 bone samples were selected for radiocarbon dating and strontium isotope analysis, respectively (Tables S1 to S4). The performed cleaning, extractions, radiocarbon

dating, isotopic and elemental analysis are described in detail in Appendix S2. Except for strontium analysis, isotopic data are reported as δ values with respect to standard references in ‰ units. All statistical tests were performed using the PAST 4.09 software (Hammer et al., 2001).

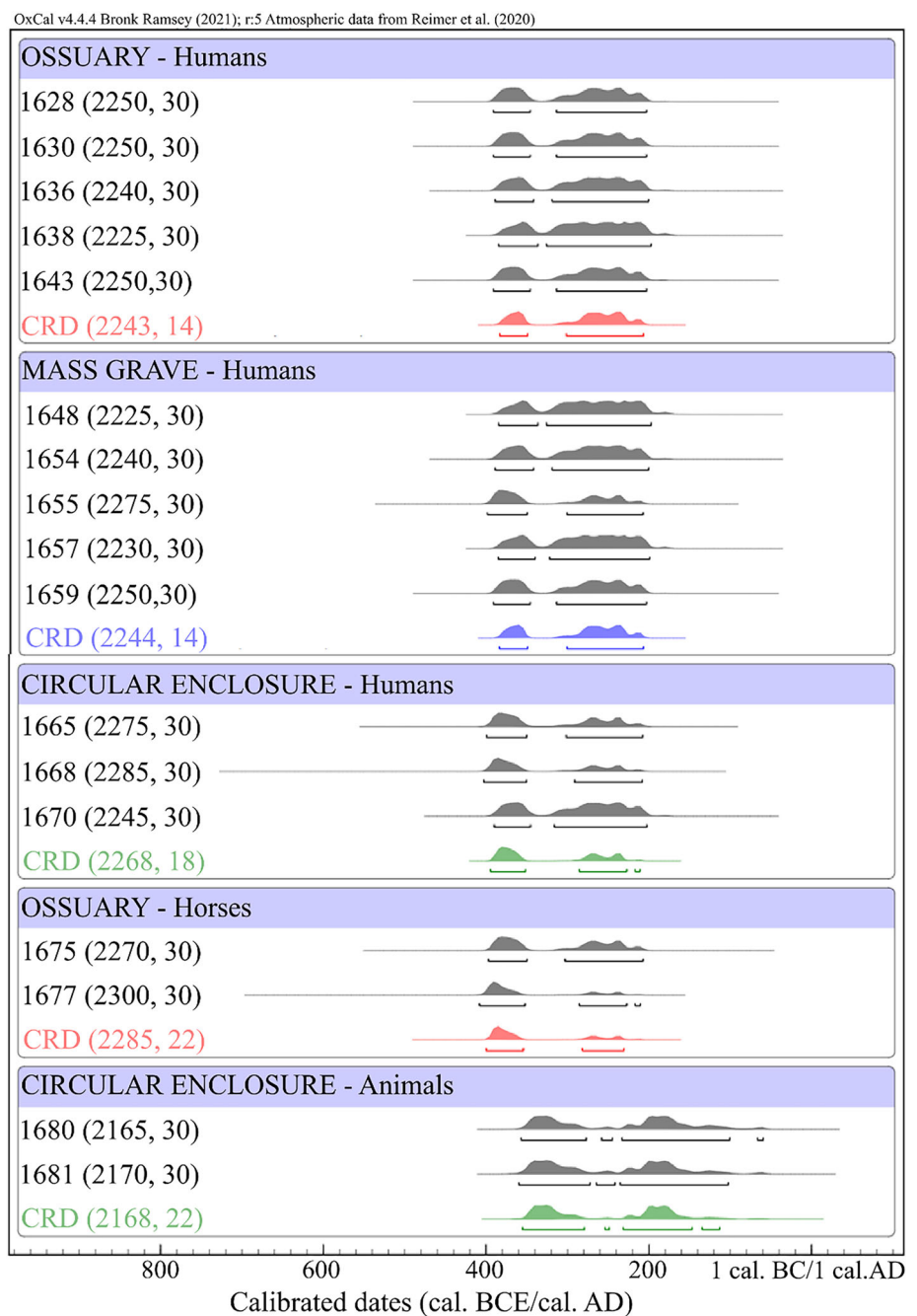
3 | RESULTS

Radiocarbon dating, radiogenic and stable isotope compositions and elemental concentrations measured in human and animal bone remains are available in Tables S1 to S4 and illustrated in Figures 2–4 and Figures S2 and S3. Stable isotope data coming from the nearby, contemporaneous archaeological site of Thézy-Glimont (Clauzel et al., 2020) is considered for discussion.

The complete data for the radiocarbon dating of the 17 samples is reported in Table S1 and illustrated in Figure 2. The combined radiocarbon date (CRD) for each structure is acquired by combining the dates obtained for all individuals before calibration. It is checked for internal consistency by a chi-squared test which is performed automatically by the OxCal™ program. The CRD obtained for the five human remains from the ossuary is 2243 ± 14 BP, corresponding to a calibrated date at 2σ (95.4%) certainty of 390–350 cal. BCE (28%) and 310–200 cal. BCE (67.6%). Considering the five human remains from the mass grave, the CRD is 2244 ± 14 BP, which corresponds to a calibrated date of 400–350 cal. BCE (54%) and 290–210 cal. BCE (41.5%). Finally, for the three human remains from the circular enclosure, the CRD is 2268 ± 18 BP, corresponding to a calibrated date of 390–350 cal. BCE (28.9%) and 310–200 cal. BCE (66.5%). The CRD obtained for the two horse remains from the ossuary is 2285 ± 22 BP, with a calibrated date of 400–350 cal. BCE (67.9%) and 290–230 cal. BCE (27.5%), whereas the two pigs from the circular enclosure give a CRD of 2168 ± 22 BP, with calibrated dates of 360–270 cal. BCE (46.8%) and 260–110 cal. BCE (48.6%).

The $^{87}\text{Sr}/^{86}\text{Sr}$ ratio of bone remains range from 0.708511 to 0.709670 for humans and from 0.708685 to 0.709360 for animals, with an overall average $^{87}\text{Sr}/^{86}\text{Sr}$ value of 0.708892 ± 0.000295 (Figure S2). The $\delta^{18}\text{O}$ values of bone bioapatite phosphate groups ($\delta^{18}\text{O}_p$) range from +16.6‰ (V-SMOW) to +18.0‰ for humans and from +16.8‰ to +18.0‰ for animals (Figure 3a). The human average $\delta^{18}\text{O}_p$ values are $+17.3 \pm 0.3\text{‰}$ for the ossuary, $+17.0 \pm 0.3\text{‰}$ for the mass grave, and $+17.4 \pm 0.3\text{‰}$ for the circular enclosure. The horses from the ossuary have an average $\delta^{18}\text{O}_p$ value of $+17.4 \pm 0.3\text{‰}$, whereas animals from the circular enclosure have an average $\delta^{18}\text{O}_p$ value of $+17.5 \pm 0.5\text{‰}$. The $\delta^{13}\text{C}$ values of bone collagen ($\delta^{13}\text{C}_{\text{coll}}$) range from -20.4‰ (V-PDB) to -17.0‰ for humans and from -23.1‰ to -21.8‰ for animals (Figure 4). The average $\delta^{13}\text{C}_{\text{coll}}$ values of humans are $-19.8 \pm 0.3\text{‰}$, $-19.3 \pm 0.7\text{‰}$ and $-19.9 \pm 0.3\text{‰}$ for the ossuary, the mass grave, and the circular enclosure, respectively. On the other hand, the average $\delta^{13}\text{C}_{\text{coll}}$ value of horses from the ossuary is $-22.5 \pm 0.2\text{‰}$, whereas it is $-22.4 \pm 0.5\text{‰}$ for the animals from the circular enclosure. The $\delta^{15}\text{N}$ values of bone

FIGURE 2 ¹⁴C dating (before present) and corresponding calibrated dates at 95.4% certainty of the human and animal bone collagen samples from Ribemont-sur-Ancre. Data are presented under the form “sample (¹⁴C date, standard deviation),” and calibrated dates are indicated on the left of the figure. Combined radiocarbon dates (CRD) are available for each studied structure and are checked for internal consistency by a χ^2 test, which is performed automatically by the oxcal™ program. [Colour figure can be viewed at wileyonlinelibrary.com]



collagen ($\delta^{15}\text{N}_{\text{coll}}$) range from +6.9‰ (AIR) to +13.0‰ for humans and from +4.6‰ to +9.8‰ for animals (Figure 4). The average $\delta^{15}\text{N}_{\text{coll}}$ values of humans are $+8.9 \pm 1.1\text{‰}$, $+10.5 \pm 0.7\text{‰}$ and $+9.7 \pm 1.2\text{‰}$ for the ossuary, the mass grave, and the circular enclosure, respectively. It is $+6.0 \pm 1.1\text{‰}$ for the horses from the ossuary and $+6.9 \pm 1.8\text{‰}$ for the animals from the circular enclosure.

The carbon (%C) and nitrogen (%N) elemental concentrations of bone collagen, together with their molar C:N ratios are available in Table S3, with average %C, %N, and C:N values of $40.3 \pm 2.2\%$, $14.5 \pm 0.7\%$ and 3.3 ± 0.1 , respectively. Elemental concentrations were measured for the samples selected for radiogenic strontium isotope analysis and are reported in Table S4 and illustrated in Figure S3.

4 | DISCUSSION

4.1 | Limitations of the study

The isotopic study of human and animal bone remains to understand archaeological sites is submitted to some limitations which need to be considered when interpreting such data. ⁸⁷Sr/⁸⁶Sr ratios are preferably measured on tooth enamel, which is more resistant to diagenesis due to lower porosity and higher crystallinity (Budd et al., 2000; Hedges, 2002), whereas tooth dentin and bone are expected to exchange with the soil and to represent the local environment (Bentley, 2006; Hoppe et al., 2003). In the case of Ribemont-sur-

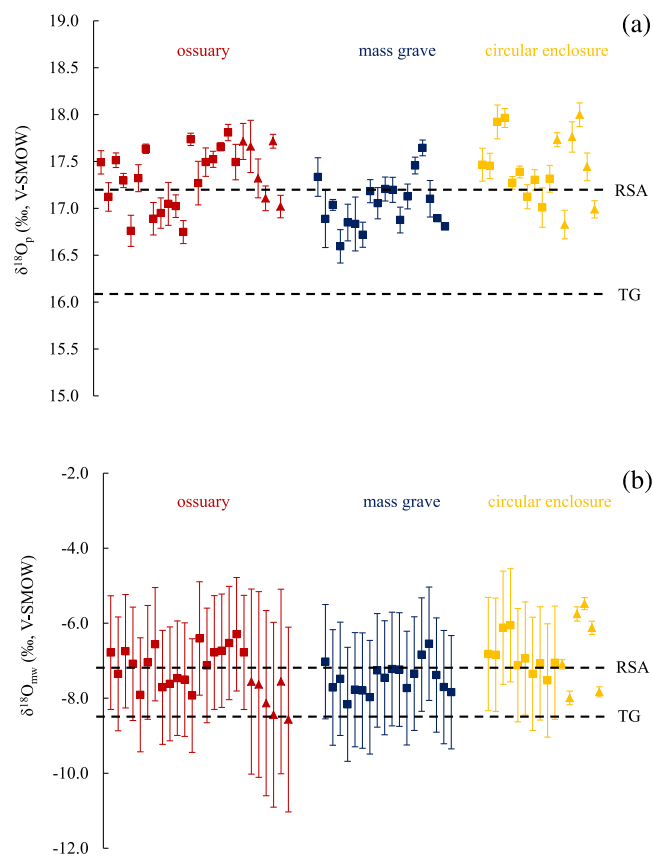


FIGURE 3 (a) Oxygen isotope values of bone bioapatite phosphate groups ($\delta^{18}O_p$, ‰ V-SMOW) from the humans (squares) and animals (triangles) of Ribemont-sur-Ancre, with the three studied structures (ossuary, mass grave and circular enclosure) evidenced. (b) Oxygen isotope values of meteoric water ($\delta^{18}O_{mw}$, ‰ V-SMOW) inferred from the bones of humans (squares) and animals (triangles) of Ribemont-sur-Ancre using the fractionation equations described in the text, with the three studied structures (ossuary, mass grave and circular enclosure) evidenced. The dashed lines correspond to the average $\delta^{18}O_p$ (a) and $\delta^{18}O_{mw}$ (b) values measured on human bone remains at Ribemont-sur-Ancre (RSA, this study) and Thézy-Glimont (TG, Clauzel et al., 2020). Refer to Table S2 for the specific value of each sample. [Colour figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com)]

Ancre, no tooth material is available due to systematic removal of the crania. The Sr isotope composition was analyzed on bone remains, and preservation from diagenesis is discussed in the following section of the discussion. As strontium contribution from the burial environment could not be excluded, the data are not used to discuss the origin of the individuals. The use of $\delta^{18}O$ values to study mobility is also subject to uncertainties such as inter-individual variability (Lightfoot & O'Connell, 2016) or large errors associated with oxygen isotope fractionation equations (Pollard et al., 2011). Therefore, specific geographic areas cannot be indicated based on this proxy alone, but more precise locations can be considered based on a body of archaeological and isotopic evidence (Lightfoot & O'Connell, 2016), such as documented in this study.

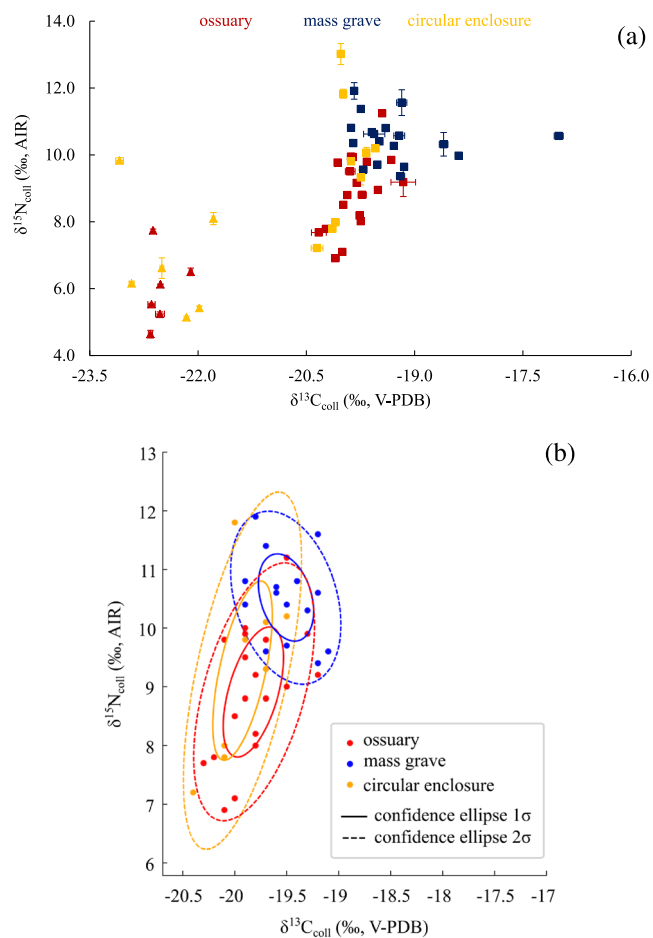


FIGURE 4 (a) Nitrogen ($\delta^{15}N_{coll}$, ‰ AIR) and carbon ($\delta^{13}C_{coll}$, ‰ V-PDB) isotope values of bone collagen from the humans (squares) and animals (triangles) of Ribemont-sur-Ancre with the three structures (ossuary, mass grave, circular enclosure) evidenced. Refer to Table S3 for the specific value of each sample. (b) Nitrogen ($\delta^{15}N_{coll}$, ‰ AIR) and carbon ($\delta^{13}C_{coll}$, ‰ V-PDB) isotope values of bone collagen from the human remains of the three structures (ossuary, mass grave, circular enclosure) of Ribemont-sur-Ancre. Confidence ellipses at 1 σ and 2 σ are represented for each group. The outliers (outside of the 3 σ confidence ellipse) have not been represented (samples #1649, #1654, #1661, #1663). [Colour figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com)]

4.2 | Preservation of the isotope signal

The isotope composition of bone remains can be altered by various processes during burial, decomposition, and fossilization (e.g., Hedges, 2002; Kendall et al., 2018). Therefore, its preservation needs to be assessed following several external, internal, elemental, and isotopic criteria. They are discussed for the bone remains of Ribemont-sur-Ancre in Appendix S3 and show that the pristine character of the isotope signal is preserved in both the mineral and the organic matrix of bones. In the case of the $^{87}Sr/^{86}Sr$ signature of bone remains, there is currently no certain way to assess its preservation. In this study, several criteria have been tested and would advocate for the absence of diagenetic alteration (Appendix S3). However, all

samples have $^{87}\text{Sr}/^{86}\text{Sr}$ that are consistent with the local burial soil and contribution from the burial environment cannot be fully excluded. Therefore, strontium data are presented in Table S2 and Figure S2 but are not discussed to assess geographic origin. We hope they will provide useful for future migration studies in the Picardie region.

4.3 | Dating and chronology of Ribemont-sur-Ancre

Human remains from the three structures are characterized by clustered ^{14}C dates, with CRD of 2243 ± 14 BP, 2244 ± 14 BP and 2268 ± 18 BP for the ossuary, the mass grave, and the circular enclosure, respectively (Figure 2). Similarly, the horses from the ossuary have a CRD of 2285 ± 22 BP. As the calibration curve IntCal20 (Reimer et al., 2020) displays a plateau during this temporal period, preventing dating accuracy, we date the individuals between 400 BCE and 200 BCE which corresponds to the La Tène B-C1 periods and agrees with the radiocarbon dates previously obtained by Fercoq du Leslay (2017). Dating similarity within the site highlights the contemporaneity of the individuals, and that the major warlike event which led to the building of the monument happened during the IIIrd-IInd centuries BCE. Although this agrees with the proposed dating of the construction of the sanctuary during the La Tène B2 to C1b periods (Brunaux et al., 2003; Fercoq du Leslay, 2017), radiocarbon dating is not accurate enough to discriminate between the different structures, except for the animal remains from the circular enclosure. Interestingly, they have a CRD of 2168 ± 22 BP with calibrated dates between 360 BCE and 110 BCE, possibly decades to one century later than the other remains. The animal remains were interpreted as leftovers from ritual sacrifices and likely banquets held in the structure after the burying of the human corpses (Fercoq du Leslay, 2017; Rose, 2020). Our results show that these rituals persisted decades to one century after the building of the sanctuary and highlights the cultural importance of Ribemont-sur-Ancre as a memoryscape dedicated to war (Rose & Fernández-Götz, 2019). It is therefore important to better understand the origin and the status of the populations involved in it.

4.4 | Geographic origin of the warriors buried in Ribemont-sur-Ancre

The geographic origin of the populations buried in the different structures of Ribemont-sur-Ancre can be assessed using stable isotope data. The oxygen isotope composition of bone bioapatite phosphate groups ($\delta^{18}\text{O}_p$) can indicate geographic mobility when it is interpreted in the frame of an archaeological context (Lightfoot & O'Connell, 2016). The $\delta^{18}\text{O}_p$ values of humans and animals within Ribemont-sur-Ancre are clustered between $+16.6\text{‰}$ and $+18.0\text{‰}$ (Figure 3a). The $\delta^{18}\text{O}_p$ value of mammals with a medium water turnover, such as humans (around 5%–10% of total body water per day,

Shimamoto & Komiya, 2000), horses and cattle, is mostly representative of the $\delta^{18}\text{O}$ value of the drinking water (Kohn, 1996; Longinelli, 1984). Drinking water is considered to source from surface waters, themselves derived from local precipitations. Using species-specific stable isotope fractionation equations, it is possible to estimate the $\delta^{18}\text{O}$ value of drinking water during the lifetime of the studied individuals, here interpreted as local meteoric water ($\delta^{18}\text{O}_{\text{mw}}$). Several $\delta^{18}\text{O}_p - \delta^{18}\text{O}_{\text{mw}}$ fractionation equations are used (Clauzel et al., 2020): Daux et al. (2008) for humans; Longinelli (1984) for pigs; D'Angela and Longinelli (1990) for bovids and Daniel Bryant et al. (1994) for equids. The estimated $\delta^{18}\text{O}_{\text{mw}}$ values are $-7.1 \pm 0.5\text{‰}$, $-7.5 \pm 0.4\text{‰}$, and $-6.9 \pm 0.5\text{‰}$ for the human individuals from respectively the ossuary, the mass grave, and the circular enclosure; $-8.0 \pm 0.5\text{‰}$ for horses and $-6.7 \pm 1.1\text{‰}$ for animals from the circular enclosure (Figure 3b, Table S2). A local range of $\delta^{18}\text{O}_{\text{mw}}$ values is necessary to infer a geographic origin of the individuals from these data. Although current isoscapes of $\delta^{18}\text{O}_{\text{mw}}$ in Europe (e.g., Bowen et al., 2005; Terzer et al., 2013) and France (Daux et al., 2021; Millot et al., 2010) are available, variations in air temperatures and humidity during the last two millennia, which have a direct impact on the $\delta^{18}\text{O}$ values of precipitations (Rozanski et al., 1993) limit the usability of modern data. Oxygen stable isotope data have been published in Clauzel et al. (2020) and consist of individuals from the nearby, contemporaneous site of Thézy-Glimont, which has been dated between 350 and 200 BCE. Based on archaeological, anthropological, and isotopic observations, the analyzed humans were interpreted as local and sedentary (Clauzel et al., 2020, 2022). Therefore, the average $\delta^{18}\text{O}_p$ value for these individuals of $+16.1 \pm 0.6\text{‰}$ ($\delta^{18}\text{O}_{\text{mw}} = -8.4 \pm 1.0\text{‰}$, $n = 7$) is used here as the local signature for the Picardie region during the La Tène B-C1 periods. The average $\delta^{18}\text{O}$ values calculated from humans at Ribemont-sur-Ancre ($\delta^{18}\text{O}_p = +17.2 \pm 0.3\text{‰}$; $\delta^{18}\text{O}_{\text{mw}} = -7.2 \pm 0.5\text{‰}$; $n = 47$) are 1.2‰ higher compared with these local values (Figure 3b). This difference could be explained by several factors, such as specific culturally mediated behaviors (Brettell et al., 2012) or individual physiological characteristics (Lightfoot & O'Connell, 2016). However, the low intra-site variability in $\delta^{18}\text{O}$ values and the fact that the enrichment of $+1.2\text{‰}$ appears to be fairly consistent within Ribemont-sur-Ancre suggests that the reason is, at least partly, a difference of geographic origin of the warriors buried in Ribemont-sur-Ancre, who may have lived in an area with ^{18}O -enriched water compared with the Picardie region. In the west of France, the $\delta^{18}\text{O}$ of precipitation gradually declines relative to its marine source when moving inland, as part of the continental effect (Rozanski et al., 1993). This $\delta^{18}\text{O}$ continental gradient has been estimated for the French Atlantic coast along the prevailing direction of air masses carried by the westerlies and is $-3.2 \pm 0.8\text{‰}$ per 1000 km (Millot et al., 2010) or $-3.7 \pm 0.3\text{‰}$ per 1000 km (Daux et al., 2021). These gradients can be applied to the Iron Age as global climatic circulation was steady during the last two millennia with climatic moisture delivered by the North-Atlantic Oscillation (Smith et al., 2016). As such, a $+1.2\text{‰}$ difference in $\delta^{18}\text{O}_{\text{mw}}$ values would correspond to a location approximately 325 to 375 km closer to the coast. Intriguingly, the resulting radius includes the area of the Maine region, near Lisieux

- Le Mans, ~350 km southwest of Ribemont-sur-Ancre, which has been previously proposed as the homeland of the vanquished warriors based on numismatic analysis (Appendix S1, Delestrée, 2001; Delestrée & Fercoq Du Leslay, 2018). The consistence between independent archaeological and isotopic data would lead us to support the Maine region as a possible origin for the buried warriors even if, based on stable isotopes alone, this is only one of several areas consistent with the data. The homogeneity of the calculated $\delta^{18}\text{O}_{\text{mw}}$ values from the human remains across the archaeological site would also argue that all studied individuals share the same origin. This is a new interpretation for the individuals from the circular enclosure, who had previously been interpreted as fallen of the victorious (local) side (Brunaux et al., 1999; Fercoq du Leslay, 2000). Our results would rather concur with the hypothesis of Rose (2020) that this structure hosted the ritual destruction of enemy corpses. Some of the horses may share the same geographic origin as the humans according to the similar calculated $\delta^{18}\text{O}_{\text{mw}}$ values, although this needs further confirmation. The animals from the circular enclosure have higher $\delta^{18}\text{O}_{\text{p}}$ ($+17.5 \pm 0.5\%$) and $\delta^{18}\text{O}_{\text{mw}}$ ($-6.7 \pm 1.1\%$) values and are very close isotopically to the cattle studied at Thézy-Glimont (Clauzel et al., 2020). They are interpreted as local and from Picardie, which is consistent with their identification as remains from ritual celebrations after the conflict.

4.5 | Diet, intra-population isotopic variations and the social status of warriors

Gallic populations were farmers who cultivated cereals and raised cattle, pigs, and sheep (e.g., Méniel, 1988; Zech-Matterne et al., 2009). Their dietary practices can be studied using carbon ($\delta^{13}\text{C}_{\text{coll}}$) and nitrogen ($\delta^{15}\text{N}_{\text{coll}}$) stable isotope compositions of bone collagen (Figure 4). Animals from the ossuary and the circular enclosure have carbon and nitrogen isotope values indicating an herbivorous diet based on C_3 -plants (DeNiro & Epstein, 1978, 1981). High $\delta^{15}\text{N}_{\text{coll}}$ values are observed for the horse #1674 due to specific physiological characteristics (Sponheimer et al., 2003) and the pigs #1680 and #1681 which were probably piglets killed before weaning.

Humans are characterized by higher average $\delta^{13}\text{C}_{\text{coll}}$ ($+3.2\%$) and $\delta^{15}\text{N}_{\text{coll}}$ ($+2.8\%$) values than those recorded in animals (Figure 4a), as would be expected for an omnivorous diet based on C_3 -plants and animal products (meat and/or dairy), in agreement with studies performed on contemporaneous sites (e.g., Clauzel et al., 2022; Knipper et al., 2017). Sample #1649 stands out with high $\delta^{13}\text{C}_{\text{coll}}$ ($-17.0 \pm 0.1\%$) and $\delta^{15}\text{N}_{\text{coll}}$ ($+10.6 \pm 0.1\%$) values, indicating different dietary habits with the possible consumption of C_4 -plants or marine food. This individual may be considered as allochthonous from the group buried in the mass grave, and his presence could be explained by his recruitment as a mercenary to go to war against the local *pagi*, as it is commonly observed among the Gauls (Pernet, 2010).

Isotopic heterogeneities are observed among humans (Figure 4): Individuals from the mass grave are characterized by higher average $\delta^{13}\text{C}_{\text{coll}}$ ($+0.6\%$) and $\delta^{15}\text{N}_{\text{coll}}$ ($+1.2\%$) values compared with the

individuals from the ossuary and the circular enclosure, which are similar isotopically (Figure 4b). When samples from those two structures are pooled to a single group and compared with the group from the mass grave through two Mann-Whitney tests for carbon and nitrogen isotope values, statistically significant differences are highlighted (p -value = 0.002 for $\delta^{13}\text{C}_{\text{coll}}$ and p -value < 0.001 for $\delta^{15}\text{N}_{\text{coll}}$). The observed difference in mean $\delta^{13}\text{C}_{\text{coll}}$ (0.6‰) is too small to be interpreted considering analytical uncertainties and isotopic variability among populations. However, the difference in $\delta^{15}\text{N}_{\text{coll}}$ is more substantial (1.2‰). Based on isotopic studies conducted on other Iron Age archaeological sites which showed that high social status warriors were characterized by a privileged access to animal protein (e.g., Knipper et al., 2014; Le Huray & Schutkowski, 2005; Moghaddam et al., 2016), a similar interpretation may be proposed here: Preferential access to animal protein (meat and/or dairy products) would explain the higher $\delta^{13}\text{C}_{\text{coll}}$ and $\delta^{15}\text{N}_{\text{coll}}$ values of the warriors of high-social status buried in the mass grave (Schwarz & Schoeninger, 1991). With the exception of two individuals from the circular enclosure who have relatively ^{15}N -enriched isotope values (samples #1663, $\delta^{15}\text{N}_{\text{coll}} = +13.0 \pm 0.3\%$ and #1667, $\delta^{15}\text{N}_{\text{coll}} = +11.8 \pm 0.1\%$) and may have been of higher social status, the individuals buried in the ossuary and the circular enclosure had significantly lower $\delta^{15}\text{N}_{\text{coll}}$ values, suggestive of more limited access to animal protein and a lower social status. Writing in the 1st century BCE, Diodorus Siculus (n.d., Historical Library, V, 29) described differences in status between those taking part in armed conflict in ancient Gaul, reporting that professional warriors brought along their retainers or *ambacti* to assist them in battle as charioteers or shield bearers. The analyzed group of individuals may correspond to this description. Based on analysis of osteological structures and anatomical connections, Brunaux et al. (2003), Fercoq du Leslay (2017) and Rose (2020) previously argued that bone material transfer existed between the mass grave and the ossuaries, whereas Ricard (2014) distinguished between the two structures, suggesting that although the mass grave comprised warriors' corpses, the ossuaries were built from remains of non-warriors or captured warriors who were ritually sacrificed. Our study concurs with this latter hypothesis, as the populations from the two structures can be differentiated based on their diet using carbon and nitrogen isotopes.

In the light of these results, we propose an updated and refined scenario from Ricard (2014) about Ribemont-sur-Ancre: The site may be associated with a single warlike event (as attested by radiocarbon dating), between a local (*Ambiani pagi*) and a non-local population (the latter potentially from the Maine region), which resulted in the victory of the local tribe and the building of the sanctuary. While remains of the defeated warriors were collected from the battlefield and piled up in the mass grave deposit (with their skulls removed and curated separately), enemies who did not die or did not participate in the battle were captured and secondarily sacrificed. Their limb remains, along with horses' long bones, were used to build the bone frames of the ossuaries within a quadrangular enclosure. Sacrifice rituals were also performed in the circular enclosure in which banquets and commemorations were held decades after the end of the conflict. Another possibility is that all sacrifices were executed in the circular enclosure, and

some of the remains were later brought to the quadrangular enclosure to build the bone frames. Complementary answers could be provided through a larger scale isotopic study of the archaeological site, especially on bone remains from structures which were not considered here.

5 | CONCLUSION

A multi-proxy approach based on radiocarbon dating, stable and radiogenic isotope analysis of bone remains from the archaeological site of Ribemont-sur-Ancre provides a better comprehension of the origin and the status of the warriors buried in the site. Radiocarbon dating of human remains highlights that they were contemporaneous and lived during the IIIrd–IInd centuries BCE, agreeing with the hypothesis of a single major conflict. Earlier dates are obtained for animal remains identified as leftovers from ritual celebrations held in the circular enclosure, highlighting the continuous use of the sanctuary, probably as a memoryscape. Although the $^{87}\text{Sr}/^{86}\text{Sr}$ signatures of bone remains were not interpreted due to potential diagenesis from the burial environment, the $\delta^{18}\text{O}$ values of bone bioapatite phosphate groups may attest that the buried warriors were non-local. Isotopic data are consistent with previous numismatic analysis and lead us to propose the Maine region as a possible origin. Carbon and nitrogen stable isotope compositions of bone collagen indicate that all human individuals followed an omnivorous diet based on C_3 -plants and animal meat, although C_4 -plants or marine products may have been consumed by some. The warriors buried in the mass grave are characterized by higher $\delta^{13}\text{C}_{\text{coll}}$ and $\delta^{15}\text{N}_{\text{coll}}$ values and may have been of high social status with a privileged access to animal protein. Conversely, the individuals buried in the ossuary and the circular enclosure had less animal protein in their diet and are interpreted as low social status warriors or servants who took part in the battle. An updated scenario of the history and organization of Ribemont-sur-Ancre is proposed in the light of these results. This study highlights the benefits of multi-proxy approaches in the case of such complex archaeological site. Here, radiocarbon dating, radiogenic and stable isotope analysis provide a new outlook on the chronology and the organization of the monument. Much is left to discover about Iron Age warfare sites to better understand the causes and origins of violence in proto-historical societies.

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CONFLICTS OF INTEREST

The authors declare no competing financial and non-financial interests.

AUTHOR CONTRIBUTIONS

TC, PR and JR collected the samples. JR and GP provided the samples and the archaeological context of Ribemont-sur-Ancre. TC, PR and ANV performed the collagen extractions. TC, JEM, FAG, RA and FF performed the isotopic measurements. TC and CL interpreted the data and wrote the manuscript with input from AVL, JPF and the other authors.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available in the supplementary material of this article.

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