Novel multidisciplinary approach detects multiple individuals within the same Late Bronze – Early Iron Age cremation graves.

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Methods

Osteoarchaeological analyses

The cremated human remains were sieved and divided into four fractions: 10+ mm, 5–10 mm, 2–5 mm, and < 2 mm. The total weight was noted per cremation deposit as well as the total weight of each fraction, except for the < 2 mm fraction since it consists mostly of soil and small pebbles. The total weight provides information on the completeness of the individual and the weight of the fractions on the degree of fragmentation. All the other archaeological material found in the remains, such as ceramic, metal objects, charcoal, silex, and glass, was noted and separated from the bone material. All the fragments (except from the < 2 mm fraction) were divided into eight skeletal categories: 1) cranium, 2) maxilla/mandible, 3) teeth, 4) axial skeleton (including clavicles, scapulae, vertebrae, ribs, and os coxae), 5) diaphysis (if possible, separated per long bone or broader categories such as lower and upper limbs), 6) epiphyses, 7) small skeletal elements (including patellae, hand and foot bones), and 8) indeterminate. Based on the presence of multiple unique skeletal elements and differences in bone robusticity (e.g. adult vs. nonadult), the Most Likely Number of Individuals (MLNI) was determined.

The combustion degree (Figure 1) was macroscopically evaluated using different variables such as colour, texture, fracture patterns, and deformation, and was attributed to a category ranging from I (charred bones) to V (calcinated bones) (Veselka, 2018).

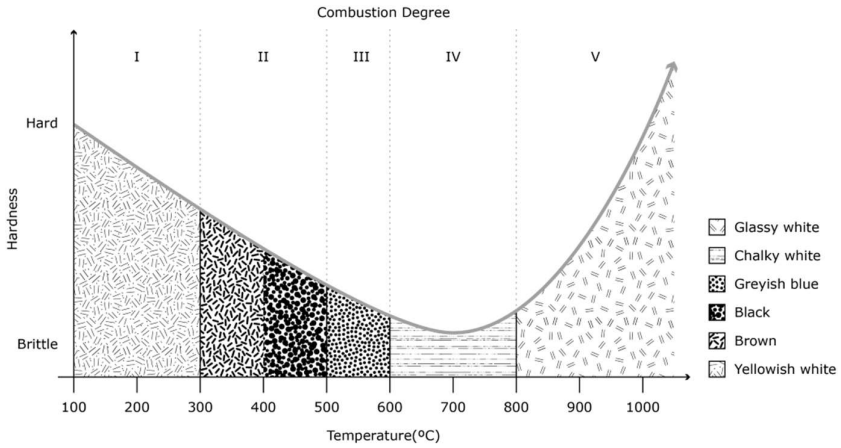

Fig. 1 – a visual representation of the combustion degree according to Wahl 2008

Adult age-at-death was estimated by combining several methods: assessment of the morphological changes to the pubic symphysis (Brooks and Suchey, 1990) and the auricular surface (Buckberry and Chamberlain, 2002), and the evaluation of the degree of cranial suture closure (Meindl and Lovejoy, 1985). The cremation process may alter the morphology of skeletal fragments and some elements required for age estimation may not be available. Therefore, broad age categories were applied: 18+ years, 22+ years, 23+ years, 19-40 years, and 40+ years.

Age-at-death of nonadults was investigated via the evaluation of the development of deciduous (Demirjian et al., 1973) and permanent teeth (Gustafson and Koch, 1974), and dental measurements (Liversidge et al., 1998). If teeth were unobservable, various cranial parts (Fazekas and Kósa, 1978) were measured and the stage of long-bone epiphyseal fusion was assessed (Schaefer et al., 2009). If possible, nonadults were assigned on of the following age categories: < 0 year, 0–6 years, 7–15 years, 15+ years, and 15–18 years. If a narrower age range could not be applied, the category 'nonadult' (< 18 years) was used.

Only adult individuals were evaluated for sex, since current macroscopic methods for nonadults do not yield sufficiently accurate results (Lewis, 2007). The sexual dimorphism of specific parts of the skeleton were assessed, such as parts of the os coxae, the cranium, and the mandible, and several measurements of long bones were taken, such as the vertical diameter of the humeral and femoral heads (Cavazzuti et al., 2019; Ferembach et al., 1980; Gonçalves, 2011; Gonçalves et al., 2013; McCormick et al., 1991; Phenice, 1969; Stewart, 1979; Steyn and İşcan, 1999). Individuals were assigned to either

one of the following categories: Female (F), Probable Female (PF), Probable Male (PM), Male (M) and Indeterminate (I).

The cremation process destroys many features, including lesions and pathological anomalies, hindering the identification of a certain disease. Although, it often is not possible to determine the specific aetiology, lesions and pathological anomalies were recorded using the standard works of Aufderheide and Rodríguez-Martín (1998), Ortner (2003), and Waldron (2009) to describe them and, if possible, conduct a differential diagnosis.

Strontium isotope analyses and concentrations

Once all visible dirt and soil had been removed mechanically using a diamond hand-held Dremel, the cremated bone fragments were pre-treated according to the procedure described in Snoeck et al. (2015). The fragments (c. 50 mg) were rinsed three times with Milli-Q™ water. For each rinsing, the samples were placed for 10 minutes in an ultrasonication bath. The samples were then treated with 1M acetic acid for 3 to 10 minutes in the ultrasonication bath and then rinsed three times with Milli-Q™ water and 10 minutes ultrasonication. Strontium was extracted from the samples and purified following the protocol described in Snoeck et al. (2015) and measured on a Nu Plasma MC-ICP Mass Spectrometer (Nu015 from Nu Instruments, Wrexham, UK) at the Université Libre de Bruxelles (ULB). During the course of this study, repeated measurements of the NBS987 standard yielded $^{87}Sr/^{86}Sr = 0.710246 \pm 45$ (2SD for >300 analyses), which is, for our purposes, sufficiently consistent with the mean value of 0.710252±13 (2SD for analyses) obtained by TIMS (Thermal Ionization Mass Spectrometry) instrumentation (Weis et al. 2006). All the sample measurements were normalised using a standard bracketing method with the recommended value of $^{87}Sr/^{86}Sr = 0.710248$ (Weis et al. 2006). Procedural blanks were considered negligible (total Sr (V) of max 0.02 versus 7–8V for analyses; i.e. ≈ 0.3%). For each sample the $^{87}Sr/^{86}Sr$ value is reported with a 2SE error (absolute error value of the individual sample

Radiocarbon dating

The bone fragments were first cleaned with a soft or a steel brush to remove any visible contaminants such as sediments present on the surface. The samples were weighted (at least 1.5 gr is needed) and then treated with hydrochloric acid (2.4 M HCl) between 1 and 10 min to remove the surface of the bone where it is more likely that carbon substitution happens and to remove sediments trapped in the bone (Van Strydonck et al., 2009). The duration of this first step depends on the sample state. The samples were removed from the solution when approximately one third of their volume was dissolved by weighting the samples before and after this step. After that, the samples were thoroughly rinsed with Milli-Q™ water and dried at 90 °C for 30 min to 1 h in an oven. When dry, the samples were weighted and reduced into fine powder in a ceramic mortar. Then they were placed in a 0.17 M acetic acid solution

during 24 h, this treatment was performed to remove the secondary carbonates possibly present. Afterwards, they were again thoroughly rinsed with Milli-Q™ water and dried between 70 and 100 °C during ~1 h (or overnight) (Wojcieszak et al., 2020).

In a next step, phosphoric acid (H_3PO_4, 85%) was added to each sample under vacuum. The CO_2 that was released was cryogenically trapped in a reactor with liquid nitrogen and transformed into graphite at 680°C using pre-treated Fe (Alfa Aesar, Iron powder, spherical, <10microns, 99.9%) as catalyst. The $^{14}C/^{12}C$ ratio in the graphite was measured using accelerator mass spectrometry (AMS) and converted into a radiocarbon age (expressed in years BP), after correction for isotope fractionation, using the $\delta^{13}C$ AMS measurement. All the measurements were obtained with the AMS type MICADAS, mini carbon dating system, at the KIK-IRPA (Boudin et al., 2015). Calibration of the radiocarbon ages (BP) into calendar years (BC/AD) was performed using the software OxCal 4.4 (Bronk Ramsey, 2009) and the atmospheric calibration curve IntCal20 (Reimer et al., 2020).

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Table S1: χ^2-test results of the radiocarbon dates, the combination of dates that did not pass the χ^2-test are marked in orange

Samples	T	5%	df
Achelse Dijk 9			
01328;08462	1.0	3.8	1
01329;08460;08461	46.3	6.0	2
08460;01329	1.8	3.8	1
08460;01329;08461;01328;08462	191.1	9.5	4
08461;01328;08462	19.4	6.0	2
Grand Bois 41			
04224;08192;04225;08192	48.4	7.8	3
08192; 04225; 08192	0.2	6.0	2
Grand Bois 23			
04226;08464;08463;04227;05097	23.6	9.5	4
08464;08463;04227;05097	3.5	7.8	3
Herstal 4			
08055; 08066	7.5	3.8	1
08055;08108	0.7	3.8	1
08066;08108	16.8	3.8	1
08100;08108;08458	21.9	6.0	2
08108;08055;08066	17.5	6.0	2
08458;08100;08066	0.2	6.0	1
08458;08100;08108	21.9	6.0	2
Herstal 6*			
04236; 08049; 08016; 04231; 01035	20.3	9.5	4
04231;01035	0.1	3.8	1
04236; 08049; 08016	2.8	6.0	2
Rekem 85-143			
08381;08382	8.0	3.8	1