Lifeway narratives of a Bronze Age community from Balatonkeresztúr (Western Hungary) based on bioarchaeological analyses

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Zusammenfassung

Lebensgeschichte einer bronzezeitlichen Gemeinde aus Balatonkeresztúr (Westungarn) anhand bioarchäologischer Analysen

Dieser Artikel konzentriert sich auf die bioarchäologischen Analysen von 19 Individuen aus bisher wenig untersuchten Populationen der frühen und mittleren Bronzezeit (2200–1600 cal BC), die in Balatonkeresztúr-Réti-dűlő (Westungarn) während der Ausgrabungskampagne vor dem Bau der Autobahn M7 2003 entdeckt wurden. 13 frühbronzezeitliche Bestattungen eines kleinen Friedhofsteils der Kisapostag/frühesten Kultur der inkrustierten Keramik wurden in zwei Grabgruppen mit zwei isolierten Körperbestattungen angeordnet. Die Bayessche Analyse weist darauf hin, dass der Friedhof zwischen 2120 und 1900 v. Chr. genutzt wurde. Die meisten Bestattungen enthielten keine weiteren Grabbeigaben. An dieser Stelle wurde auch eine ungewöhnliche Mehrfachbestattung mit acht Personen entdeckt, die in die mittlere Bronzezeit zwischen 1770 und 1620 cal BC datiert wird. Analysen dieser menschlichen Überreste sind wichtig für die Zeit, in der die Feuerbestattungspraxis in der Region des heutigen Westungarn üblich war. Archäologische, anthropologische und Radiokarbonuntersuchungen wurden durch Strontiumisotopenmessungen und alte DNA-Daten ergänzt, um die Dynamik der am Fundort Balatonkeresztúr entdeckten Gemeinschaften zu rekonstruieren. Die aDNA-Analysen ergaben, dass die Population der Kisapostag/frühesten Kultur der inkrustierten Keramik die genetische Grundlage der nachfolgenden Gemeinschaft der Kultur der inkrustierten Keramik war und dass die soziale Struktur beider Kulturen patrilokal war, ähnlich wie bei den meisten untersuchten zeitgenössischen Gruppen.

Summary

This paper focuses on the bioarchaeological analyses of 19 individuals from previously understudied Early and Middle Bronze Age (2200–1600 cal BC) populations, discovered at Balatonkeresztúr-Réti-dűlő (Western Hungary) during the excavation campaign preceding the construction of the M7 motorway in 2003. Thirteen Early Bronze Age burials of a small cemetery part of the Kisapostag/earliest Encrusted Pottery culture were arranged into two grave groups with two isolated inhumations. Bayesian analysis indicates that the cemetery was used between 2120 and 1900 cal BC. Most of the burials contained no remaining grave goods. An unusual multiple burial with eight individuals was also discovered at this site, dated to the Middle Bronze Age period between 1770 and 1620 cal BC. Analyses of these human remains are important in the period, when the cremation burial practice was common in the region of modern-day Western Hungary. Archaeological, anthropological and radiocarbon investigations were complemented by strontium isotope measurements and ancient DNA data to reconstruct the dynamics of the communities discovered at the site of Balatonkeresztúr. The aDNA analyses revealed that the population of the Kisapostag/earliest Encrusted Pottery Culture was the genetic basis of the succeeding community of the Encrusted Pottery Culture and the social structure of both cultures were patrilocal, similarly to most studied contemporaneous groups.

1. Introduction

In the last centuries of the 3rd millennium BC (2200–2000/1900 cal BC; parallel with the beginning of Central European Early Bronze Age; Bertemes/Heyd 2015; Fischl et al. 2015), during the final phase of the Early Bronze Age in Hungary, the population groups of the Kisapostag/earliest Encrusted Pottery Culture existed in Western Hungary, while the population of the tell cultures inhabited the Great Hungarian Plain. During this period, fahlore copper jewellery are the most characteristic metal finds (Kiss 2020; Kiss 2020a). Before the 1990s, the practice of urn cremation burials was solely associated with this culture. In the last decades, in addition to urn burials and scattered cremations, around 90 inhumation burials of this culture have been documented. Interpretation of the biritual burial practice have been proposed with both chronological and social explanations (s. Kiss 2015; Kiss 2020). The results of new excavations and radiocarbon dating of these recently discovered inhumations indicate that the dominant burial tradition in the earlier phase was inhumation. Deceased were placed in the grave on their sides in a sleeping position, or sometimes on their back, with their legs pulled up, often without any grave goods. Less frequently, a small mug next to the head and personal orna-

ments/jewellery (e.g., tiny tubular beads made of sheet copper or hair rings) were found as grave goods. In a later period of the culture (Kisapostag phase 2), cremation began to be practiced and became dominant (Somogyi 2004; Szabó 2010; Kiss 2012; Hajdu et. al 2016).

The Middle Bronze Age in Hungary (parallel with the younger phase of the Central European Early Bronze Age, Reinecke Br A2; 2000/1900–1600/1500 cal BC) is the flourishing period of the tell-settlements in the Great Hungarian Plain, and the Transdanubian Encrusted Pottery Culture in large areas of Western Hungary, e.g., beside Lake Balaton. Tin bronze weapons and tools appear in all spheres of everyday life during this period, including the Tolnanémedi type hoards in the western part of Hungary, and the Hajdúsámson type metallurgy in the northeastern region of the Carpathian Basin. Fahlore copper is continuously used, while at the end of the Middle Bronze Age chalcopyrite raw material is more widespread. Local production of metallurgy is proven by the moulds found in the settlements[1]. Cremation burial practice (urn graves and scattered cremation burials) were applied nearly exclusively among the groups of the Transdanubian Encrusted Pottery Culture, with cemeteries separated from the settlements (Kiss 2012).

Early and Middle Bronze Age settlements at Balatonkeresztúr

The Balatonkeresztúr-Réti-dűlő site is located 3 km from the southern shore of Lake Balaton. In 2003–2004 an area of 45 000 m² was investigated at this site, preceding the construction of the M7 motorway. As a result, the traces of occupations associated with nine archaeological cultures spreading over eight chronological periods were identified by the analysis of 2976 archaeological features. These include: the Middle and Late Copper Age (Balaton-Lasinja, Furchenstich, Boleráz and Baden Cultures); Early Bronze Age (Somogyvár-Vinkovci and Kisapostag/earliest Encrusted Pottery Cultures); Middle Bronze Age (Transdanubian Encrusted Pottery Culture); Late Iron Age (La Tène D); Migration period (Langobards); Árpádian Age (12th–13th century); and Late Middle Ages (14th–15th century; Fábián/Serlegi 2009).

The settlement of the Kisapostag/earliest Encrusted Pottery and Transdanubian Encrusted Pottery Cultures at the site of Balatonkeresztúr can be interpreted as part of open settlements, consisting of a few buildings, storage and refuse pits (Kiss 2012).

Early Bronze Age cemetery of the Kisapostag/earliest Encrusted Pottery Culture at Balatonkeresztúr

Ancient DNA analyses of the remains of Copper and Bronze Age individuals discovered at Balatonkeresztúr-Réti-dűlő and Balatonlelle-Rádpuszta have revealed the genetic ancestry of the population living on the southern shore of Lake Balaton during that period (21 individuals, between 3500 and 1600 cal BC; Kiss et al. 2015; Bondár/Szécsényi-Nagy 2020; Gerber et al. 2023). Based on these results, this paper focuses on the bioarchaeological analyses of 19 Early and Middle Bronze Age (2200–1600 cal BC) burials from Balatonkeresztúr (Fig. 1). Due to the lack of grave goods, human remains were dated based on ^{14}C dates. Altogether 13 burials of the Kisapostag/earliest Encrusted Pottery Culture were discovered (~ 2200–1900 cal BC), 12 inhumations and one cremation burial, from which 11 were suitable for bioarchaeological analyses. We conducted physical anthropological, stable isotope, and aDNA analysis of these burials from Balatonkeresztúr. Burials without grave goods were not typically evaluated during earlier research, however, these inhumations provide the basis for understanding social processes, possible kinship ties and the genetic makeup of the Bronze Age, due to the widespread cremation burial practice of the study period.

The preservation condition of the human remains (stored in the Rippl-Rónai Museum, Kaposvár) was medium to poor. In the case of most of the skulls, the facial part was reconstructed only in a few cases, while the postcranial remains were relatively well preserved (Fig. 2; Fig. 3a–e). The estimation of age-at-death and the sex determination were based on the methods commonly used in physical anthropology[2]. The paleopathological lesions were investigated macroscopically (Manchester 1983; Aufderheide/Rodríguez-Martín 1989; Ortner 2003).

At the northeastern part of the excavated settlement of the Kisapostag/earliest Encrusted Pottery Culture at Balatonkeresztúr, a small cemetery with 13 burials was discovered with one cremation burial (S12) among them. Most of the burials were spatially distributed into two grave groups (Group A: individuals S1, S2, S3, S5, S6, S7, n = 6; and Group B: individuals S4, S8, S11, S13, n = 4), while one inhumation, found a little further from the two burial groups, was a grave of a young male individual (S10). Another older male (S45) was found further west. All inhumations were sampled for bioarchaeological analyses except S3, due to the nearly complete destruction of the body (Fig. 1; Tab. 1). Most burials contained no grave goods; however, in three cases, small non-diagnostic pieces of copper jewellery were found (Grave S10, S13 and S12 cremated). The deceased were placed in a flexed position, laying on their side (Fig. 2; Fig. 3a–b). Most skeletons show slight or modest distortion. Though the skeletal material was poorly preserved, and osteological sex determination was difficult in a few cases (e.g., children), the biological sex could be determined through aDNA analysis. Group A consists of three juveniles and three adults, five males and a female (individual S7), while in Group B we found one juvenile male, and three adults, two males and one female (Grave S13). Inhumation burials altogether represented four juveniles and eight adults. Radiocarbon dates place these inhumations between 2200–1800 cal BC (95.4 %); however, with Bayesian analysis using the OxCal software the timespan of the burials from this period can be reduced

1 Kiss 2009; Kiss 2012; Fischl et al. 2013; Dani et al. 2016; Dani et al. 2019; Dani et al. 2020.

2 Fazekas/Kósa 1978; Ferembach/Schwidetzky et al. 1979; Işcan/Loth et al. 1984; Işcan/Loth et al. 1985; Ubelaker 1989; Bernert et al. 2007.

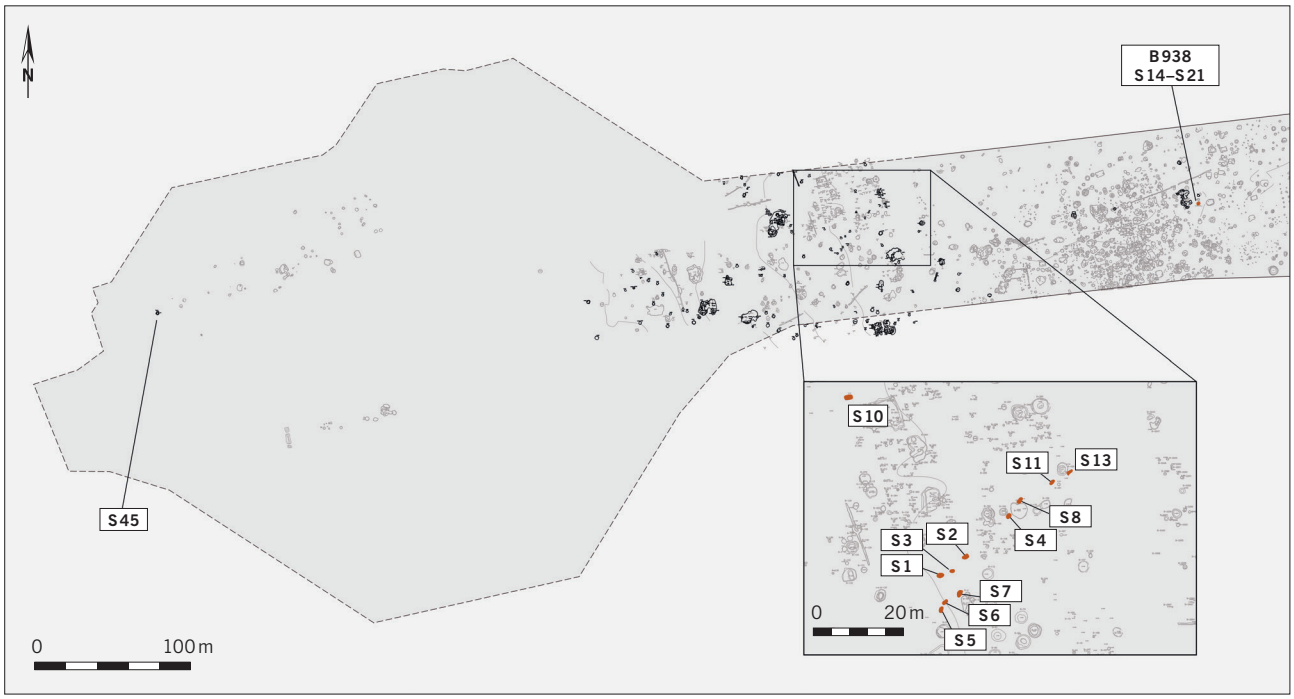


Fig. 1 Early and Middle Bronze Age settlement features (with black) and burials (with numbers) at Balatonkeresztúr-Réti-dűlő site, Somogy County.

Abb. 1 *Siedlungsbefunde der frühen und mittleren Bronzezeit (schwarz) und Bestattungen (s. Ziffern) am Fundort Balatonkeresztúr-Réti-dűlő, Komitat Somogy.*

Group	ID	Grave group	^{14}C (cal BC) 2σ (95.4 % CI)	Age	Sex	MtDNA	ChrY	Degree of genetic relatedness
Kisapostag/ earliest Encrusted Pottery Culture	S1	A	2120–1880	40+	M	V	I2a-L1229	2nd to S2 (& S8?)
	S2	A	2120–1880	30–35	M	U5a2b1a	I2a-L1229	2nd to S1 (& S8?)
	S4	B		17–19	M	H10a1	I2a-L1229	1st to S8
	S5	A		16–18	M	T1a4	I2a-L1229	1st to S6 & S11
	S6	A	2030–1770	17–18	M	T1a4	I2a-L1229	1st to S5 & S11
	S7	A	2120–1880	35–50	F	V		
	S8	B		30–40	M	T2b	I2a-L1229	1st to S4; (2nd to S1 & S2?)
	S10		2140–1940	7–8	M	K1a4a1g	I2a-L1229	None
	S11	B	2200–1980	34–43	M	T2b	I2a-L1229	1st to S5 & S6
	S13	B	2120–1890	35–45	F	J2b1		None
	S45		2200–1980	45–55	M	U5a1g	I2a-L1229	None
Transdanubian Encrusted Pottery Culture	S14	Mass Grave B-938		7–8	F	H10a1		None
	S15			21–23	M	U4b1b1	I2a-L1229	2nd to S17
	S16		1890–1640	35–44	M	T2g2	I2a-L1229	None
	S17		1870–1540	26–35	M	U5b1b1+@16192	I2a-L1229	1st to S19; 2nd to S15
	S18			3–4	M	U4a2	R1b-Z2103	None
	S19			9–10	M	T2b	I2a-L1229	1st to S17
	S20			1.5–2	M	K1a+195	R1b-Z2103	1st to S21
	S21			1.5–2	F	K1a+195		1st to S20

Tab. 1 Balatonkeresztúr-Réti-dűlő. Summary of the data of investigated human remains.

Tab. 1 *Balatonkeresztúr-Réti-dűlő. Zusammenfassung der Daten der untersuchten menschlichen Überreste.*

to 2050–1940 cal BC with an 84.4 % probability, whereas only two graves were possibly slightly earlier. The overall pathological makeup of the population does not show evidence for significant disease and the average biological age of the adults was high (s. Tab. 1).

Fig. 2a–i Human remains from the Bronze Age at Balatonkeresztúr-Réti-dűlő. a S1; b S2; c S4; d S5; e S6; f S7; g S8; h S10; i S11.

Abb. 2a–i *Menschliche Überreste aus der Bronzezeit in Balatonkeresztúr-Réti-dűlő. a S1; b S2; c S4; d S5; e S6; f S7; g S8; h S10; i S11.*

Anthropological data

Grave S1, Group A (Fig. 2a). The body was placed on the right side in a flexed position, with a north-east–south-west axis orientation. One piece of a flint was found in the grave pit. Sexualisation index: -0.18. The remains consist of fragmented skeletal bones and a skull, which were ^{14}C-dated to 3611 ± 31 BP (2120–1880 cal BC, 95.4 % CI), and determined to be a male of over 40 years (determination of age at death based on tooth abrasion: level 5). Among the 29 teeth present, three upper and one lower molar were decayed *(caries)*. The lower right first molar is missing *ante mortem*, indicated by the healed *alveolus*. Other pathological conditions were not revealed. The skull has a *brachycranic* and likely *planoccipital* shape, a feature which is almost ubiquitous within this group.

Grave S2, Group A (Fig. 2b). The remains and endogenous DNA are poorly preserved and fragmented. The body was placed on the left side in a flexed position, with a north-east–south-west axis orientation. Several non-diagnostic pieces of Bronze Age pottery were found in the burial pit. In absolute terms the grave was dated to 3609 ± 32 BP (2120–1880 cal BC, 95.4 % CI). The body was determined to be a male of 30–35 years (determination of age-at-death based on tooth abrasion: level 3). Sexualisation index: -0.50. No molar decay was determined on the remaining 12 teeth, and the skull type is brachycranic and likely planoccipital. A rare anatomical variation of perforated fossa olecrani can be observed on the left humerus.

Grave S3, Group A. Human bone frangments in a grave pit. The remains were not suitable for the bioarchaeological analyses.

Grave S4, Group B (Fig. 2c). The deceased was placed on the right side in a flexed position, with a slight north-east–south-west axis orientation. The human remains consisted of only a small amount of fragmentary bone material and teeth. Sexualisation index: -0.20. The remains of a 17–19 year-old male individual (determination of age at death based on muscular adhesion surfaces, and tooth abrasion: level 2) had 16 remaining teeth with no visible pathological conditions. One boar incisor and fragmentary pottery were recovered from the grave. Radiocarbon dating was not performed as the remains can be dated by the genetically determined father, individual S8.

Grave S5, Group A (Fig. 2d). Moderately preserved remains of a 16–18 year-old male individual in a flexed position, with a north–south axis orientation. Only several non-diagnostic Bronze Age pottery sherds were found in the grave. The determination of age at death was based on muscular adhesion surfaces, and tooth abrasion: level 2–3. The male had 32 remaining teeth and the skull type was brachycranic and likely planoccipital. Besides some severely decayed molars (left upper first molar: *caries*) no other pathological conditions could be observed. Some fragmentary pottery was also recovered from the grave. The ^{14}C-dating was not performed as the remains can be dated by the genetically determined father, individual S11.

Grave S6, Group B (Fig. 2e). The body was placed on the left side in a heavily flexed position, with a north-east–south-west axis orientation. The moderately preserved bone fragments were ^{14}C-dated to 3571 ± 31 BP (2030–1770 cal BC, 95.4 % CI), and belonged to a 17–18 year-old male individual (sexualisation index: +0.71; determination of age-at-death based on muscular adhesion surfaces, and tooth abrasion: level 2). The male had 24 remaining teeth, and besides one decayed molar (right lower first molar: *caries*), no other visible pathological conditions were revealed on the skeletal remains.

Grave S7, Group A (Fig. 2f; Fig. 3c). Moderately preserved remains of a 35–50 year-old female individual (sexualisation index: -0.18; determination of age-at-death was based on sutures ossification, and tooth abrasion), who was ^{14}C-dated to 3611 ± 32 BP (2120–1880 cal BC, 95.4 % CI). The skull was of brachycranic type with a long facial structure. Besides 28 remaining teeth (with no *caries*), some were missing ante mortem (right lower second premolar and second molar, and left lower second premolar). Extended porotic lesions were found in the skull (os frontale and parietale), in addition to some enthesopathy, i.e., bone spikes caused by heavy labour on the right calcaneus (left was not examined because of its fragmentary condition). No grave goods were recovered from the grave besides some non-diagnostic Bronze Age pottery sherds.

Grave S8, Group B (Fig. 2g). The body was placed on the left side in a flexed position, with a north-east–south-west axis orientation. The poorly preserved bones belonged to a 30–40 year-old male (sexualisation index: +0.80; determination of age-at-death based on abrasion of teeth: level 4, sutures ossification and the surface of *facies auricularis*) with a calculated stature of 168.2 cm. Just like individual S2, the body had an anatomical variation of perforated fossa olecrani on the right humerus, likely as a result of biological relationship. Only four teeth remained, showing no signs of decay *(caries)*. On the diaphysis of his right tibia periostitis was observed, while both calcanei showed signs of enthesopathy.

Grave S10, which was located farther from Group A, was the only child grave among the burials of this period (Fig. 2h). The moderately preserved remains of a 7–8-year-old male individual (determination of age-at-death based on teeth, and size of long bones) were found and ^{14}C-dated to 3661 ± 30 BP (2140–1940 cal BC, 95.4 % CI). The skeleton was placed in a flexed position, with a north-east–south-west axis orientation. The bones did not show any sign of pathological conditions. A copper or bronze bracelet on the arm suggested a higher social status for this individual.

Grave S11, Group B (Fig. 2i; Fig. 3d). Moderately preserved remains of a 34–43-year-old male (sexualisation index: +1.16, determination of age-at-death based on the trajectory of the proximal epiphysis of the *humerus* and *femur* and abrasion of the remaining 26 teeth: level 3), which was ^{14}C-dated to 3705 ± 30 BP (2200–1980 cal BC, 95.4 % CI). The skeleton was placed in a flexed position, with a north-east–south-west axis orientation. The dolichocranic skull was highly deformed under soil pressure. The bones are distorted, similarly to many other individuals from this archaeological culture. The calculated stature of the individual was 171.9 cm. He had a severe walking disabililty of the left leg owing to an early-life injury or a developmental

Fig. 3a–f Human remains from the Bronze Age at Balatonkeresztúr-Réti-dűlő. a S13, b S45; c S7 skull; d S11 skull; e S13 skull; f S15 skull.

Abb. 3a–f *Menschliche Überreste aus der Bronzezeit in Balatonkeresztúr-Réti-dűlő. a S13, b S45; c S7 Schädel; d S11 Schädel; e S13 Schädel; f S15 Schädel.*

disorder. The grave contained some non-diagnostic Bronze Age pottery sherds.

Grave 12, Cremation burial; not included in the bioarchaeological analyses.

Grave 13, Group B (Fig. 3a,e) included the well-preserved remains of a 35–45-year-old female. The body was placed on the left side in a flexed position, with a north–south axis orientation. The remains had a strange body placement compared to other individuals, with her right arm covering the face, implying special treatment for this individual. Several fragments of metal beads made of copper sheet were placed at the left side of the head along with a small burnt animal bone fragment, and traces of green patina on the right side of the skull were found. Copper or bronze bead fragments associated with the headdress or cap ornament found in the grave suggest that she had a relatively high social status within the community. According to radiocarbon dating (3618 ± 30 BP; 2120–1890 cal BC, 95.4 % CI), her burial

most probably can be dated to between 2040 and 1890 cal BC (90.9 %). Sexualisation index: -0.81; determination of age-at-death was based on sutures ossification, the surface of *facies symphyses* and tooth abrasion: level 4–5. The skull is of *brachycranic* type, the calculated stature of the body was 158.7 cm, which can be considered the average stature of females during this era. This individual had a rare anatomical variation of extra sutural bones and maxillary prognathy. While 29 of her teeth remained, *caries* was observable only on the lower left second molar; the lower left third molar had fallen out *ante mortem*. The only pathological conditions were one missing and one decayed tooth. There was no sign of an external injury or illness on her body, so the cause of her death is currently unknown. Analyses on pelvis bones suggest no or few birth-giving events during her lifetime. The remains of the skull were the best preserved among all individuals in the site, which enabled facial reconstruction, grave reconstruction and a detailed anthropological description for this individual using genetic data (Kustár et al. 2022; Gerber et al. 2023).

Grave S45 (Fig. 3b) The moderately preserved remains of a 45–55-year-old male individual were laid next to a typical Kisapostag-associated pit with a west–east axis orientation. It was located a significant (more than 300 m) distance from the other Kisapostag-associated graves. Broken pottery and considerable amounts of shell fragments were also recovered. The individual had no grave goods, although shell fragments could be observed right next to the human bones, and the individual was buried in a heavily flexed position facing towards the North. The remains were ^{14}C-dated to 3702 ± 28 BP (2200–1980 cal BC, 95.4 % CI). A significant abrasion of the upper teeth can be observed with slight mandibular prognathism, likely in association with some sort of profession or behavioural anomaly that caused bruxism (Gerber et al. 2023). The skull is curvoccipital and mesochycranic, the mandibles are slightly protruding, perhaps in relation with the bruxism.

Middle Bronze Age multiple burial

The later horizon of the human remains is represented by a multiple pit burial of eight individuals including three adults and five children (cf. Fig. 1; Tab. 1, S14–21; Fig. 4–5) from the period of the Transdanubian Encrusted Pottery Culture. Due to the lack of other finds, the feature was formerly defined as a household refuse pit used for mortuary purposes sometime in the Late Copper Age or the Early Bronze Age (Fábián 2006). However, based on the *brachycran taurid* type skull, anthropological analyses suggested a Bronze Age dating (Köhler 2006). Radiocarbon dates proved that this multiple burial can be dated to between 1870–1620 cal BC (95.4 %; cf. Tab. 1; also Gerber et al. 2023), parallel with the developed Early Bronze Age in Central Europe (Reinecke Br A2; Fischl et al. 2013; Kiss et al. 2019). The physical anthropological examinations detected the presence of the *planoccipital brachycranic taurid* type *crania*, a physical trait which could be linked to the Bell Beaker Group (Zoffmann 2000; Köhler 2006). The discovery of this multiple burial is significant in the context of cremation burial tradition (urn burials and scattered cremations), which was practised nearly exclusively by the population of the Transdanubian Encrusted Pottery Culture during this period (Kiss 2012). Prior to our examination, only a few data were available concerning the physical anthropological makeup of these communities (Zoffmann 2000; Zoffmann 2008).

Anthropological data of the multiple burial B-938

Individual S14 (Fig. 4; Fig. 5a) revealed a 7–8-year-old female child, whose body was placed on the right side, with a south–north axis orientation. The upper body was in a prone position with heavily flexed legs. The skull and skeletal bones were relatively well-preserved and determination of age-at-death was based on the teeth and the length of long bones.

Individual S15 (Fig. 3f; Fig. 4; Fig. 5a) was a 21–23-year-old male, whose body was lying on the right side with flexed legs, oriented on a north–south axis. The remains consisted of medium-preserved skeletal bones and a skull. Determination of age-at-death was based on the trajectory of the proximal epiphysis of the *humerus* and *femur*. Based on the sexualisation index (-0.43) the individual was osteologically determined as a female (Köhler 2006). The skull was short, broad, and *hyperbrachycyran* according to the index; alveolar prognathism was moderate (for details see Köhler 2006, Tab. 1). The calculated stature of the body on the basis of the size of the long bones was in the tall category: 174.2 cm (Köhler 2006, Tab. 2). Pathological conditions included hip dysplasia (*luxatio coxae congenita*) in both *femurs* and the pelvis. The heads of both *femurs* are severely deformed, with thinning of the diaphysis, and the thickened *fibulae* are also characteristic for this illness. No *caries* was observed on the 32 teeth; level 2 tooth abrasion.

Individual S16 (Fig. 4; Fig. 5b) was a 35–44-year-old male whose body was lying on the right side with slightly flexed legs, with west–east axis orientation. The remains consisted of a medium-preserved skull and relatively well-preserved skeletal bones. The characteristics of the skull were determined to be moderately masculine but the gracility of the skeleton suggested a female with a sexualisation index of (± 0.00). Determination of age-at-death was based on the trajectory of proximal epiphysis of the *humerus*, the surface of *facies symphyseos ossis pubis* and abrasion of the teeth and *femur* (Köhler 2006). The skull was short and very broad in absolute dimensions and *hyperbrachycranic*; alveolar prognathism was moderate (Köhler 2006, Tab. 1). The calculated stature of the body on the basis of the size of the long bones indicates the individual fell within the small-medium category of 151.2 cm (Köhler 2006, Tab. 2). Anatomical variation revealed *ossa wormiana* on both sides of the skull. Pathology: sacralisation of the final part of the vertebra and entesopathy on both *calcaneus* were observed. No *caries* was observed on the 31 remaining teeth, but a small amount of *calculus* was visible; level 4 tooth abrasion.

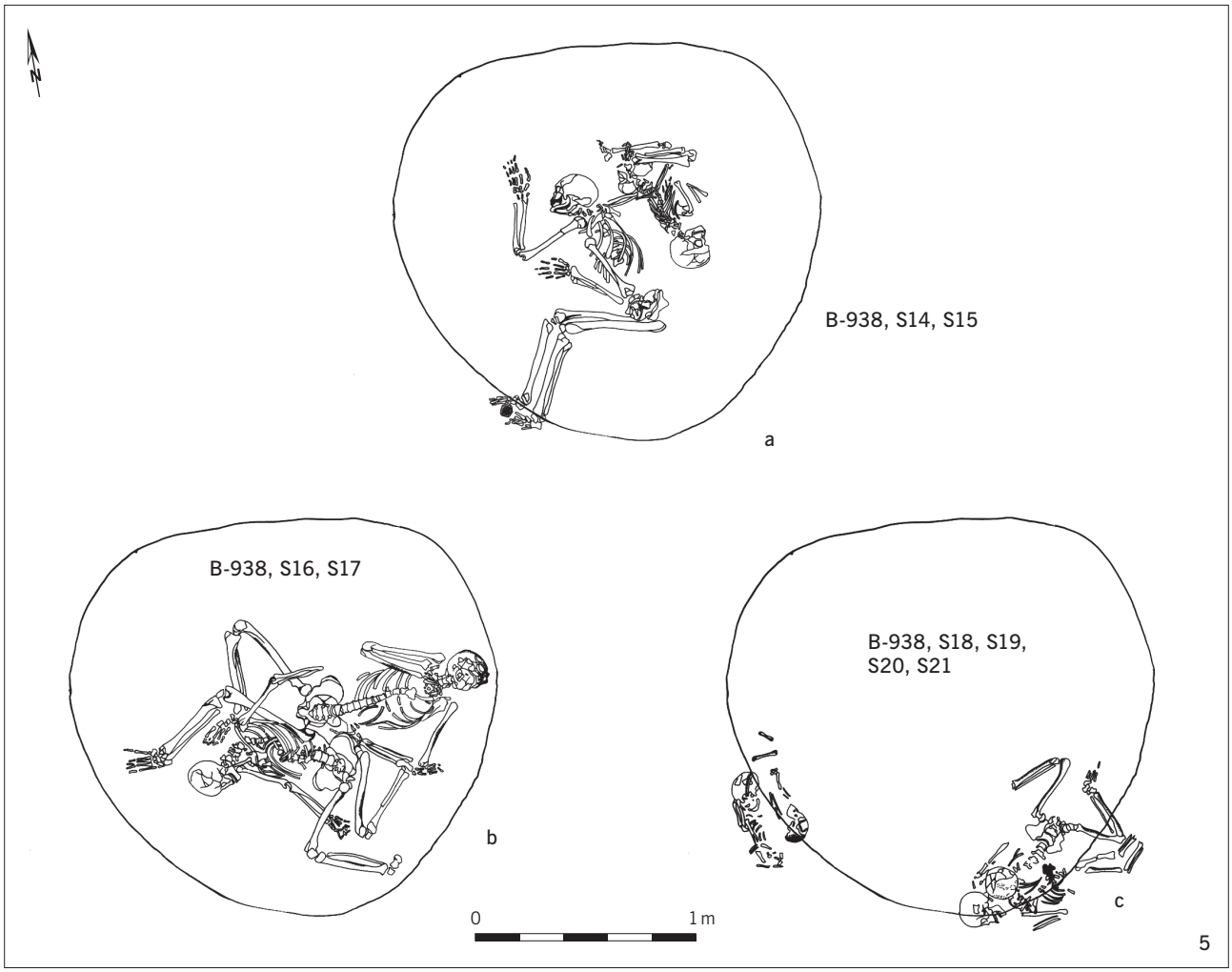
Individual S17 (Fig. 4; Fig. 5b). A 26–35-year-old male. The upper body was in a supine position, with bent legs on the right side. The body was oriented on an east–west axis. The remains consisted of a medium-well preserved skull, and a relatively well-preserved postcranial skeleton. Determina-

Fig. 4 Human remains from the Bronze Age at Balatonkeresztúr-Réti-dűlő, multiple burial B-938: S14–S21.

Abb. 4 *Menschliche Überreste aus der Bronzezeit in Balatonkeresztúr-Réti-dűlő, Mehrfachbestattung B-938: S14–S21.*

Fig. 5 Three layers of human remains from the Bronze Age at Balatonkeresztúr-Réti-dűlő, multiple burial B-938: S14–S21.

Abb. 5 *Menschliche Überreste aus der Bronzezeit in Balatonkeresztúr-Réti-dűlő, Mehrfachbestattung B-938: S14–S21.*



tion of age-at-death was based on the ribbed surface of the *facies symphy-seos ossis pubis*, the trajectory of the proximal epiphysis of the *humerus*, and the abrasion of the teeth. The sexualisation index was average (+0.70). The skull was short, broad, *hyperbrachycephalic*, and had a planoccipital profile (Köhler 2006, Tab. 1). The calculated stature was high: 173.5 cm (Köhler 2006, Tab. 2). Anatomical variations: *ossa wormiana* on the sides of the skull were visible. Pathology:

incomplete *sacrum bifidum*, enthesopathy on both *tibiae*. On the inner side of the left medial surface of the pelvis a 1.8 × 1.8 cm area suggests the presence of a tumour during life. No *caries* was observed on the 31 remaining teeth, with small amount of *calculus*, tooth abrasion level 3.

Individual S18 (Fig. 4; Fig. 5c) was a 3–4-year-old male child, whose body was lying on the right side with slightly flexed legs, and a west–east axis orientation. The remains consisted of a fragmentary skull with moderately preserved, incomplete postcranial skeletal bones. Determination of age-at-death was based on the abrasion of teeth and the length of the long bones.

Individual S19 (Fig. 4; Fig. 5c) was a 9–10-year-old male child, whose upper body was in supine position, with bent legs on the right side, and oriented on a south–north axis. The remains consist of a fragmentary skull and skeletal bones. Determination of age-at-death was based on the abrasion of teeth and the length of the long bones. Anatomical variation revealed *ossa wormiana* on both sides of the skull.

Individual S20 (Fig. 4; Fig. 5c) was a 1.5–2-year-old male child, whose body lay on the right side with slightly flexed legs and oriented from south–north. The remains consisted of a poorly preserved skull and fragmentary, incomplete postcranial skeletal bones. Determination of age-at-death was based on the abrasion of teeth and the length of the *humerus*. Pathology: lesions were observed on the long bones, especially along the muscle joints, as well as on the skull.

Individual S21 (Fig. 4; Fig. 5c) was a 1.5–2-year-old female child with very fragmented bones. The individual was lying in flexed position and oriented on a north–south axis. Determination of age-at-death was based on the length of the tibia (Köhler 2006, Tab. 2). According to genetic analyses individuals S20 and S21 were dizygotic twins.

Bioanthropological analyses: Sr isotope and genetic ancestry of the Balatonkeresztúr populations

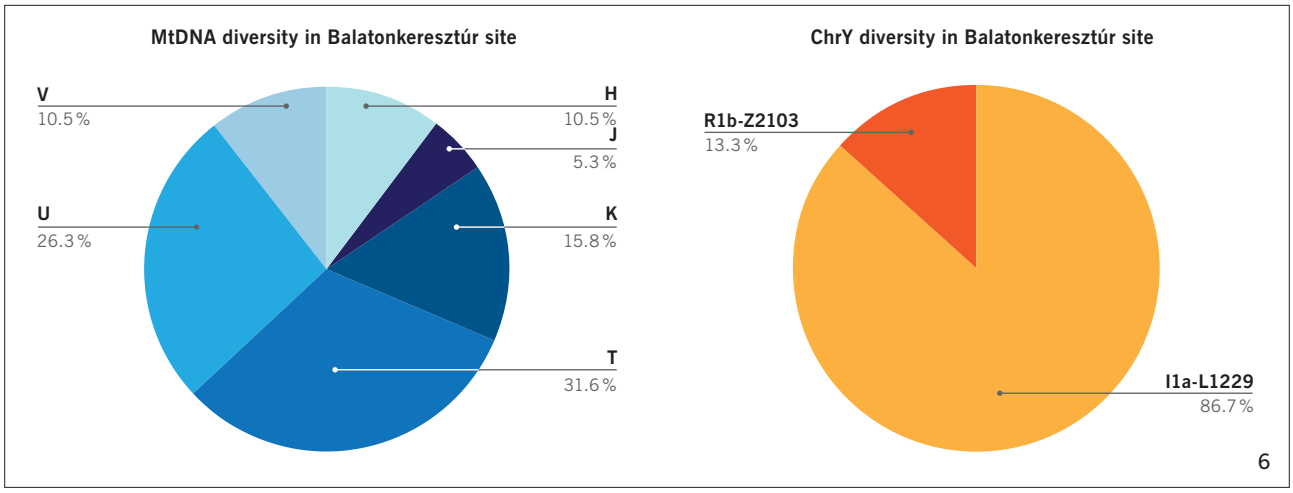
Dental enamel samples from Early Bronze Age burials (S1–13, S45) were analysed for their strontium isotope ($^{87}Sr/^{86}Sr$) ratios by the ICER laboratory, Atomki, Debrecen (Hungary), while samples of the Middle Bronze Age multiple burial (S14–20) were analysed at the Center for Anthropological Research (CAR) at Quinnipiac University and the Yale Metal Geochemistry Center (Department of Geology and Geophysics at Yale University (for details of methodology see Gerber et al. 2023). The first molar was sampled, or the second/third molar if the first was not available. In the case of the multiple burial, the first and third molars were both sampled. According to our results (Tab. 2) the radiogenic strontium isotope data ($^{87}Sr/^{86}Sr$) from all of the Balatonkeresztúr individuals were consistent with »local« values of the biologically available strontium ratio measured from plants, water and soil from the region to the south of Lake Balaton (calculated by taking the mean value of the published plant and water samples: Alt et al. 2014) plus or minus two standard deviations. There were no significant differences between males and females or subadults versus adults. The samples from the multiple burial of the Transdanubian Encrusted Pottery culture (Pit: B-938, S14–20) were slightly less radiogenic and more variable than the earlier time periods. This is particularly apparent for samples from three individuals (S15, S16, and S17) where the first and third molars were sampled. While both values could have come from the region south of Lake Balaton, they exhibit some spread, indicating movement within the region during the early adolescence period of their life.

The archaeogenetic studies were carried out in the Institute of Archaeogenomics, Research Centre for the Humanities in Budapest, Hungary with state of the art NGS (Next Generation Sequencing) methodology (for details see Gerber et al. 2023). Samples were taken from Early Bronze Age human remains in accordance with the international standards: from the *pars petrosa* of the temporal bone or, in the absence of it, from tooth material. DNA library preparation for shotgun sequencing was carried out in dedicated sterile laboratory facilities following the most recent methodology (Dabney et al. 2013; Rohland et al. 2015; Lipson et al. 2017). An average of 5 million DNA fragments (reads) were randomly shotgun-sequenced per sample, using the sequencing platforms Illumina MiSeq and NovaSeq. Bioinformatical analyses consisted of raw sequencing read-filtering and mapping to the human reference genome (hg19 version) and post-filtering data processing. We called for 1.240 million Single Nucleotide Polymorphisms (SNPs) from the genomes, a frequently used genomic SNP panel in ancient DNA analyses (Mathieson et al. 2015), from which an average of 101 thousand SNPs per sample were retrieved from the population of this study. This was a sufficient amount for various population genetic analyses, including PCA and allele-frequency-based methods, and even for a – limited – phenotypic variant discovery (Walsh et al. 2014; Walsh et al. 2017; Chaitanya et al. 2018).

Male dominance (~ 78 %) in both periods suggest distinctive funeral treatment for males and females. However, in other cemeteries of the same community (e.g., Ordacsehi and Bonyhád in Hungary), males, females and children were buried close to each other, suggesting high variance of burial practices (Somogyi 2004; Hajdu et al. 2016).

According to the results, the Kisapostag/earliest Encrusted Pottery population had a high level of hunter-gatherer (HG) genetic ancestry, compared to other Bronze Age groups of the region, beside genetic material of the Anatolian farmers and the Yamnaya component from the steppe[3]. Based on the extensive population genomic analyses (for details see Gerber et al. 2023) the origin of this outstandingly high HG ancestry can be traced back to previously overlooked regions in Eastern Europe, such as today's Ukraine, Moldavia, Romania or Belarus Belarus. New results (Chyleński et al. 2023) supports this assumption. Biological connections of this population in the wider area could have been traced back via this peculiar ancestry. Population

3 Gamba et al. 2014; Allentoft et al. 2015; Brandt et al. 2015; Haak et al. 2015; Lipson et al. 2017; Mathieson et al. 2018; Olalde et al. 2018.



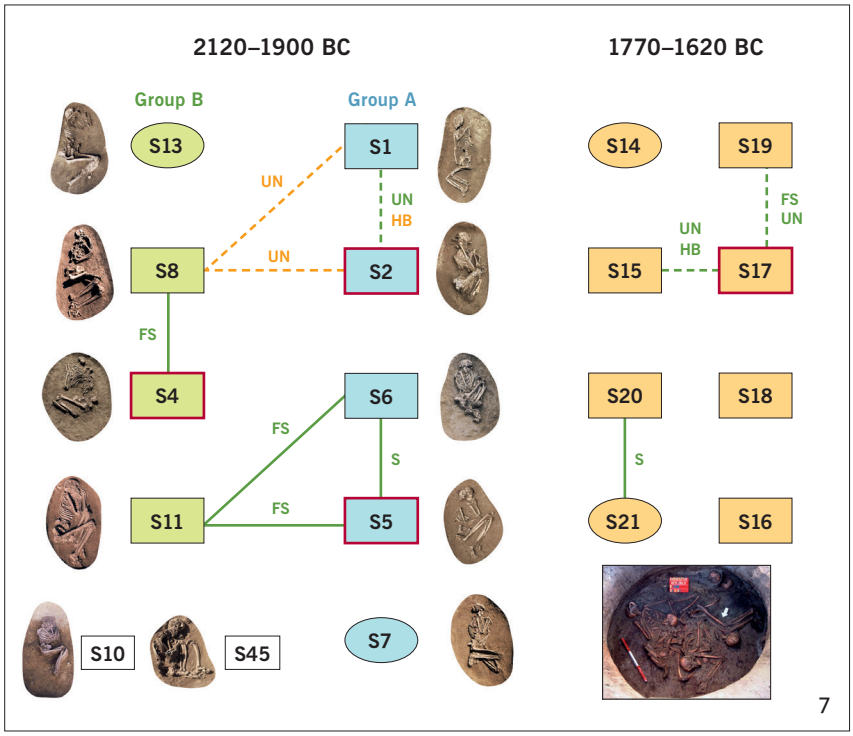


Fig. 6 Mitochondrial DNA and Y chromosomal haplogroups or the ratio of maternal and paternal lineages in the genetic dataset of Balatonkeresztúr-Réti-dűlő from the Bronze Age.

Abb. 6 *Mitochondriale DNA und Y-chromosomale Haplogruppen oder das Verhältnis der mütterlichen und väterlichen Abstammungslinien im genetischen Datensatz von Balatonkeresztúr-Réti-dűlő aus der Bronzezeit.*

Fig. 7 Genetic relatedness network of Early and Middle Bronze Age burials at Balatonkeresztúr site (solid lines represent first degree, dashed lines second degree relationships; green line represents proven, orange unproven but possible relationships; FS: father-son, UN: uncle-nephew, S: siblings, HB: half brother). In three cases, more than one relation type can explain the scarce genetic data.

Abb. 7 *Genetisches Verwandtschaftsnetzwerk von Bestattungen aus der frühen und mittleren Bronzezeit am Fundort Balatonkeresztúr (durchgezogene Linien stellen Beziehungen ersten Grades dar, gestrichelte Linien zweiten Grades; FS: Vater-Sohn, UN: Onkel-Neffe, S: Geschwister, HB: Halbbruder). In drei Fällen kann mehr als ein Beziehungstyp die knappen genetischen Daten erklären.*

genetic analyses uncovered that the main ancestry component (~ 60 ± 8 %) for the Transdanubian Encrusted Pottery Culture individuals was the Kisapostag/earliest Encrusted Pottery Culture population. Differences mostly driven by female-biased admixture with various local populations, which was genetically best represented in the currently available dataset by Transdanubian Late Bronze Age or Early and Middle Bronze Age Maros Culture data from modern-day Serbia (Freilich et al. 2021; Patterson et al. 2022; Gerber et al. 2023). This indicates not only cultural but also genetic continuity between the two communities (detected by archaeological and anthropological data also in the cemetery of Bonyhád; Hajdu et al. 2016).

Accordingly, numerous contemporaneous populations show admixture with the Kisapostag/earliest Encrusted Pottery and/or Transdanubian Encrusted Pottery associated population from Czechia to Serbia. The transition of Kisapostag to Encrusted Pottery in the Balatonkeresztúr site was followed by the dilution of their characteristic ancestry most likely by female-biased admixture of local populations, as paternal lineages remained mostly unchanged between periods (cf. Tab. 1; Fig. 6). This supports that female exogamy, detected elsewhere as a general phenomenon in the Bronze Age (Mittnik et al. 2019), can also be observed among this population living in the vicinity of Lake Balaton, although this may have been limited in distance according to the local strontium isotope signature.

Biological relatedness and Bayesian modelling of radiocarbon dates

Biological relatedness analyses are important to reveal social structures in prehistory lacking written records or human documentation. Kisapostag/earliest Encrusted Pottery Culture is represented by three relationships; green line repre-

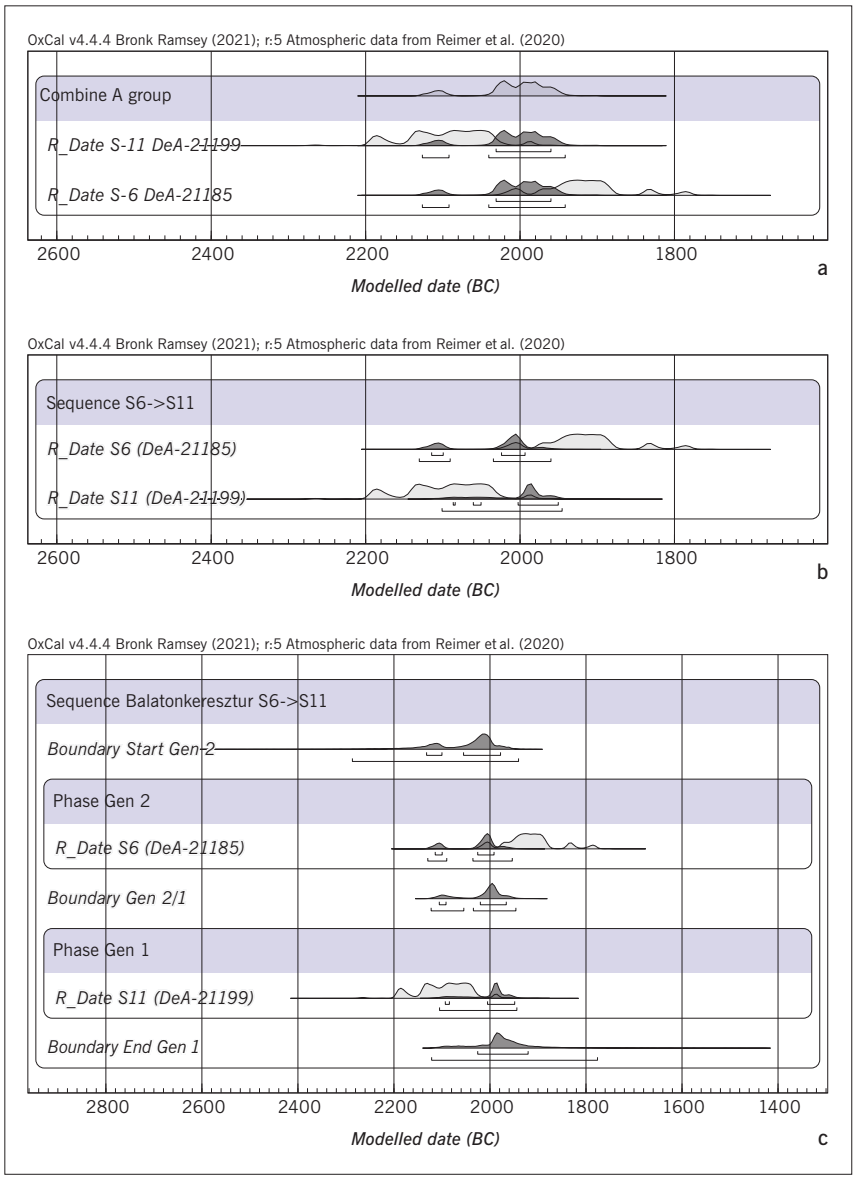


Fig. 8a–c Modelled radiocarbon dates. a Modelled radiocarbon dates of samples S6 and S11 from the Balatonkeresztúr site; b Modelled radiocarbon dates of samples S6 and S11 from the Balatonkeresztúr site (a multiplot, where S6 precedes S11); c Modelled radiocarbon dates of samples from the Balatonkeresztúr site for individuals S6 and S11.

Abb. 8a–c *Modellierte Radiokarbondaten. a Modellierte Radiokarbondaten der Proben S6 und S11 vom Fundort Balatonkeresztúr; b Modellierte Radiokarbondaten der Proben S6 und S11 vom Fundort Balatonkeresztúr (ein Multiplot, bei dem S6 vor S11 steht); c Modellierte Radiokarbondaten von Proben aus der Fundstelle Balatonkeresztúr für die Individuen S6 und S11.*

sents proven, orange unproven but possible relationships; FS: juveniles (16–19 year-old) and seven adults (30+ year-old) distributed into two spatial groups: Grave Group A and B (cf. Fig. 1; Tab. 1). One child grave (individual S10) and the burial of another adult male (S45) were further away from the others. The absence of children from the site is a phenomenon which often can be observed in the cemeteries of prehistoric and early historic periods and can be traced back to different preservation dynamics or burial practices of adults (Mende 2000), while the reason for the absence of young adults (~ 20–30 year olds) is unknown.

According to the results of the uniparental and the autosomal *READ* (Monroy Kuhn et al. 2018; cf. Günther in this volume)/MPMR (Modified Pairwise Mismatch Rate, Gerber et al. 2023) genetic relatedness analyses, a number of first- (parent-offspring, siblings) and second-degree paternal (on the Y-chromosomal lineage identical) relations were found within the Kisapostag/earliest Encrusted Pottery Culture Group. The kinship network of the population approximately follows the distribution of individuals in Grave Groups A–B, which were likely established along family relationships and chronology (Fig. 7): ascendants, i.e., the earliest members of the group, were also the genetically most distant (i.e., highest huntergatherer ancestry component) individuals compared to others represented in Grave Group B, while their children and likely grandchildren and/or nephews were in Grave Group A. The distant inhumations (S10, S45) did not show a biological relationship to any other individuals up to second degree.

Individuals from the Middle Bronze Age multiple burial also showed a few blood relations (Fig. 7): a half-brother or uncle-nephew, a father-son and dizygotic twins (the oldest detection of such relatedness to our knowledge). Based on these results, this pit cannot be considered as a single blood-related family »mass grave«. However, we also have to bear in mind that possible further connections may have remained hidden due to low genomic coverages of the samples. Several recent archaeological studies emphasise that prehistoric social kinship relations were not necessarily determined by biological links (Brück/Frieman 2021; Mittnik et al. 2019), and it is possible to assume second marriage due to higher female mortality (Rebay-Salisbury 2017). So we

have to note that the interpretation of an extended family group cannot be excluded in the case of the multiple burial.

Most male individuals in both periods belong to the Y chromosome haplogroup I2a-L1229, except for two haplogroups R1b-Z2103 (cf. Tab. 1). This uniparental makeup shows a patrilocal social structure that is similar to previously reported Bronze Age findings (Mittnik et al. 2019; Schroeder et al. 2019; Žegarac et al. 2021), and results also resemble to previous observations about the Encrusted Pottery Culture's population at the Jagodnjak site, Croatia (Freilich et al. 2021).

Radiocarbon dating was performed for all Bronze Age horizons of the site at the HEKAL AMS ^{14}C facility of the Institute for Nuclear Research, Debrecen (Molnár et al. 2013; Molnár et al. 2013a), except for individual S16, which was measured at the VERA AMS facility in Vienna. The dates were calibrated with the OxCal v4.4 software using the IntCal20 Northern Hemisphere radiocarbon calibration curve (Bronk Ramsey 2009; Reimer et al. 2020; all calibrated dates are presented at 2σ range, unless indicated otherwise). Overall 10 samples have been radiocarbon-dated from the 19 burials published here: eight samples from Kisapostag/earliest Encrusted Pottery period (four from Grave Group A: S1, S2, S6 and S7, two from Grave Group B: S11 and S13, and two from isolated graves, S10 and S45), while two individuals were sampled from the Middle Bronze Age mass grave (S16 and S17). The dates from the graves of the Kisapostag/earliest Encrusted Pottery Culture range between 2200 and 1770 cal BC, however, with Bayesian analysis using the OxCal software the timespan of the burials can be reduced to ca. 2120–1900 cal BC (95.4 % CI), with two graves (individuals S10 and S11) possibly being slightly earlier (s. Gerber et al. 2023).

In recent years it has been recognized that archaeogenetic analysis and information on relatedness can provide further prior chronological information (Fig. 8a–c) that can be built into the Bayesian modelling of radiocarbon dates (Sedig et al. 2021; Massy et al. 2022). A new software, refinedate, was developed to perform such analyses. Nevertheless, OxCal software is also perfectly capable of including and analysing such information. Here we used Oxcal, following an earlier study (Massy et al. 2022). There is a first-degree (father-son) relationship between indiviual S11 from Grave Group B and individual S6 from Grave Group A. Since the father (S11) died at the age of 34–43, and the son at the age of ca. 17–18 years, it may be assumed that their dates of death were rather close, if not even simultaneous. Although we obviously cannot be certain of this, we combined these to date a single event. The combined date for their deaths (Fig. 8a) is 2130–1940 cal BC (95.4 % CI), within this boundary dates between 2050 and 1940 cal BC have a significantly greater probability (84.4 % CI).

In the case of a 17 year-old son and a 43 year-old father it is also possible that the son died earlier, which we may use as prior chronological information (Massy et al. 2022). This scenario was also modelled. Since this prior information seems to reverse the order of these two dates (which is also indicated by OxCal through the poor agreement values), modelling them should actually place significant constraints on their ranges. We can model them in two ways. We may simply place these dates into a sequence where individual S6 precedes individual S11 (Fig. 8b). In this case the 2σ date for S6 is 2140–1960 cal BC, where the period of 2040–1960 cal BC has greater probability (68.9 %). The date for S11 is 2110–1940 cal BC.

The other way is to place these two dates into a model with two phases, where the data of the son represents the earlier phase (generation), and that of the father the latter (Fig. 8c). Here S6 is dated to 2130–1950 cal BC, where the range between 2040 and 1950 has greater probability (73.5 %), and S11 is dated to 2110–1940 cal BC. Thus, both models indicate roughly the same dates for the deaths of these individuals.

The dates of the Middle Bronze Age multiple burial fall between 1890 and 1540 cal BC (Tab. 1). Since the context and the full articulation of the skeletons indicate that the individuals deceased at the same time or within a short time of each, the two dates were combined to date a single event. The combined date for the mass grave is 1870–1620 cal BC (95.4 % CI), within this boundary the timespan between 1770 and 1620 cal BC has a significantly greater probability (93.1 % CI; s. Gerber et al. in press, Suppl.).

Lifeway narratives of the Bronze Age community from Balatonkeresztúr

The cultural relations and origin of the Early Bronze Age communities in the Carpathian Basin have been explained with various ways, mainly with the arrival of population groups from the east (Yamnaya Culture), from the west (Bell Beaker Groups), and from the south (Vučedol and Somogyvár-Vinkovci Groups). According to these views newcomers also brought with them the technology and know-how of bronze metallurgy (Bóna 1975; Bóna 1992). The pottery decoration technique (the so-called reeled-stick decoration) of the Kisapostag/earliest Encrusted Pottery Culture, appearing in the last phase of the Early Bronze Age according to the Hungarian relative chronology (c. 2200/2150 cal BC; RBA1), was connected to the Middle Dnieper region (Ukraine) or epi-Corded Ware Groups (northern Carpathians, e.g. Chłopice-Veselé, Slovakia). Similarities of burial positions in connection with the Corded Ware were also were pointed out (Bóna 1961; Bándi 1984; Hajdu et al. 2016). However, local development of communities connected to eastern (Makó-Kosihy-Čaka Culture) or southern (Somogyvár-Vinkovci Culture) origins, as well as western and southwestern contacts (with the Litzenkeramik or Guntramsdorf-Drassburg Group in Eastern Austria, Slovenia, and western Croatia) were also raised in the archaeological literature (Bóna 1992; Črešnar 2010; Kiss 2015). Moreover, the Bell Beaker influence was mentioned in relation to the craniometry data: the so-called *Glockenbecher* or *brachycranic* skull type (Mozsolics 1942; Zoffmann 2000; Köhler 2006).

Bioarchaeological analyses of the Early and Middle Bronze Age burials from Balatonkeresztúr (cf. Tab. 1) indicate that the genomic ancestry of the Early Bronze Age Kisapostag/earliest Encrusted Pottery Culture population was previously unknown from Central Europe (from a later

Laboratory ID	Laboratory	Burial/Specimen	Tooth Sampled	$^{87}Sr/^{86}Sr$
I/2584/2	ICER Laboratory, Atomki	Balatonkeresztúr, S1	Second molar	0.709843
I/2584/3		Balatonkeresztúr, S2	Second molar	0.709790
I/2584/4		Balatonkeresztúr, S4	Second molar	0.709797
I/2584/5		Balatonkeresztúr, S5	Second molar	0.709896
I/2584/6		Balatonkeresztúr, S6	First molar	0.709778
I/2584/7		Balatonkeresztúr, S7	First molar	0.709969
I/2584/8		Balatonkeresztúr, S8	Second molar	0.709802
I/2584/9		Balatonkeresztúr, S9	Third molar	0.709692
I/2584/10		Balatonkeresztúr, S10	Second molar	0.709716
I/2584/11		Balatonkeresztúr, S11	Second molar	0.709763
I/2584/12		Balatonkeresztúr, S13	Second molar	0.709757
I/3273/1		Balatonkeresztúr, S45	Third molar	0.709820
CAR0995	Quinnipiac University, Yale Metal Geochemistry Center	Balatonkeresztúr, S14 (Pit B-938)	First molar	0.709413
CAR0991		Balatonkeresztúr, S15 (Pit B-938)	First molar	0.709562
CAR1016		Balatonkeresztúr, S15 (Pit B-938)	Third molar	0.708721
CAR0992		Balatonkeresztúr, S16 (Pit B-938)	First molar	0.709482
CAR1015		Balatonkeresztúr, S16 (Pit B-938)	Third molar	0.709284
CAR0993		Balatonkeresztúr, S17 (Pit B-938)	First molar	0.709530
CAR1014		Balatonkeresztúr, S17 (Pit B-938)	Third molar	0.708945
CAR0994		Balatonkeresztúr, S18 (Pit B-938)	First molar	0.709588
CAR0990		Balatonkeresztúr, S19 (Pit B-938)	First molar	0.709613
CAR0996		Balatonkeresztúr, S20 (Pit B-938)	First molar	0.709432

Tab. 2 Radiogenic isotope data for Balatonkeresztúr site samples.

Tab. 2 *Radiogene Isotopendaten für Proben von dem Fundort Balatonkeresztúr.*

period see: Freilich et al. 2021). The aDNA analyses revealed that the Kisapostag/earliest Encrusted Pottery population can be connected to newcomers in the Carpathian Basin, most probably arriving from Eastern Europe, in line with the earlier archaeological assumptions of several scholars (Bóna 1961; Hajdu et al. 2016). Strontium ($^{87}Sr/^{86}Sr$) isotope ratio data from molars (Tab. 2) indicate that every individual investigated in this study was raised and lived in at least close proximity to the Balatonkeresztúr site in their childhood and early adolescence. This suggests that individuals of this grave group do not represent the first generation of the Kisapostag/earliest Encrusted Pottery Culture associated population in Transdanubia (Western Hungary). This group, which had settled in the southern shore of Lake Balaton, was the genetic basis of the succeeding community of the Transdanubian Encrusted Pottery Culture, which was also suggested by Bronze Age research based on pottery typochronology (Kiss 2012; Hajdu et al. 2016). The specific genetic makeup of newcomers diluted the culture generation by generation, but it remained characteristic for centuries in the region (in details: Gerber et al. 2023). The homogeneity of paternal lineages suggests a social organisation similar to the patrilocal residence system during the Early and Middle Bronze Ages of the region (Schroeder et al. 2019; Freilich et al. 2021). Local values of strontium isotope data, along with similar genomic makeup of both sexes suggest exogamy most probably occurred between communities of the same population living in distant villages. Grave groups were established along family relationships. Genetic data from other Encrusted Pottery Culture sites (e.g., Jagodnjak, Croatia; Freilich et al. 2021) also support that communities belonging to the culture may have been based on families along the male line or a clantype society.

Considering the unstructured age and kinship distribution in the multiple burial compared to the earlier phase, the coetaneous death of at least eight people and the absence of traumatic or ritual events on bones (in contrast e.g., with what was detected by Meyer et al. 2009; Szeverényi et al. 2019), and the non-normative (non-cremated) nature of the burial all point to a sudden tragic event in the Transdanubian Encrusted Pottery period (between 1800–1600 cal BC), as first suggested based on the anthropological analyses (Köhler 2006). The position of the deceased placed in the pit, similar to earlier inhumations of the same society, support an interpretation that these individuals were buried by their own community for a special reason (most probably an infection caused by pathogens not detectable on their bones).

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2 S. Fábián
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