[Supplementary material]

The problem with tells: absolute dating of Bronze Age mortuary ceramics in Hungary

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Dating cremated bone

Most of the dated bone from Békés 103 is calcined from body cremation, and requires careful consideration. First, during combustion, calcification occurs while the samples are in an environment with other carbon sources (atmosphere, bone collagen and fuel). The carbon exchange between these sources during combustion is part of a complicated process that makes it impossible to date the human carbon alone with any confidence, so dating of cremains is subject to the problem of "old wood" (Olsen *et al.* 2013; Snoeck 2014; Snoeck *et al*. 2016). However, we do not consider this a debilitating challenge, because the Great Hungarian Plain and surrounding environment suffered tremendous deforestation by the end of the Copper Age, and Bronze Age fuel was unlikely from old wood sources (Willis *et al*. 1998; Sümegi 2004). Second, carbon-based salts from the burial environment may have precipitated onto or into the cremated remains. Experiments and contextual comparison, however, indicate that the burning process increases the crystal size and density of the mineral structure, making it more resistant to mineral exchange post-burning (Snoeck *et al*. 2014, 2016). Therefore, combustion temperatures high enough to form large crystals and dense mineral structure mitigate against the possibility of diagenesis. We assessed the chemical composition of cremated bone samples from Békés 103 using Fourier Transform Infrared Spectroscopy (FTIR) and the results indicate the bone was

highly calcined and crystalized, with little variation within and between burials (Quarato & Giblin 2017).

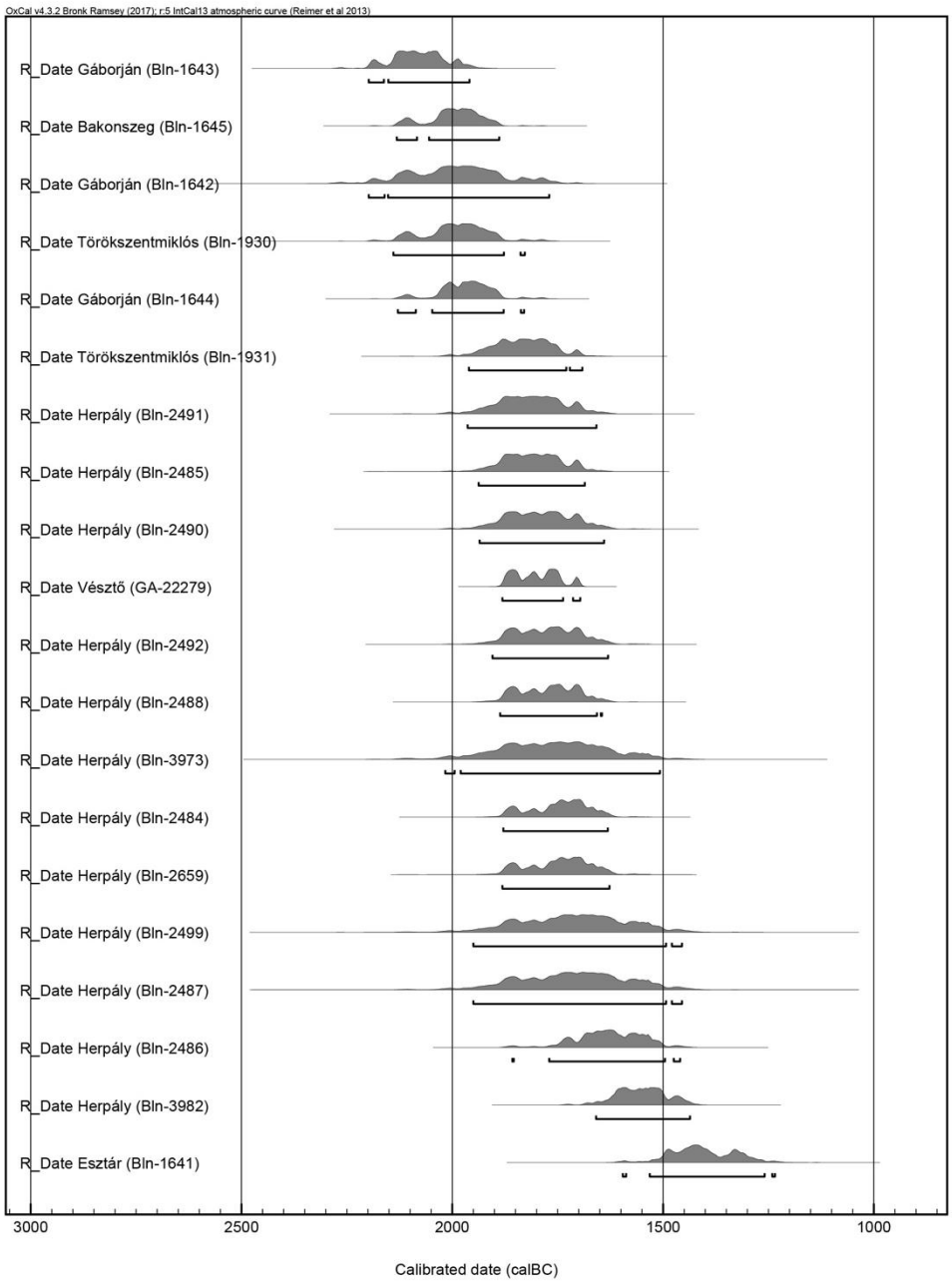

Figure S1. Calibrated dates for Bronze Age tells in the Lower Körös Basin: Esztár-Fenyvespart, Gáborján-Csapszékpart, Berettyóújfalu-Herpály, Bakonszeg-Kádárdomb, Vésztő-Mágor, and Törökszentmiklós-Terehalom. The sample for Vésztő-Mágor, previously unpublished, is of the lumbar vertebra of a juvenile Bos *from levels 8, 9, Gyulavarsánd III according to Hegedűs and*

Makkay (1987: 88–89), excavated by the Körös Regional Archaeological Project during work in 2014 (Block C1B2, EU2-2) (Parkinson et al. *2018). It is an AMS date, run on collagen at the University of Georgia, and gives a date of 3470±25 (1875–1745 cal BC at 68.2 per cent).*

Table S1. Radiocarbon dates for tells in the Körös area of the Great Hungarian Plain.

Lab ID	Uncal bp	±	Site	Culture	Source
Bln-1643	3690	40	Gáborján-Csapszékpart	Ottomány (early)	Raczky *et al*. 1994
Bln-1645	3625	40	Bakonszeg-Kádárdomb	Nyírség	Raczky *et al*. 1994
Bln-1642	3620	75	Gáborján-Csapszékpart	Ottomány (early)	Raczky *et al*. 1994
Bln-1930	3620	50	Törökszentmiklós-Terehalom	Hatvan	Raczky *et al*. 1994
BLn-1644	3605	40	Gáborján-Csapszékpart	Ottomány/Gyulavarsánd	Raczky *et al*. 1994
Bln-1931	3510	50	Törökszentmiklós-Terehalom	Hatvan	Raczky *et al*. 1994
Bln-2491	3490	60	Berettyóújfalu-Herpály	Ottomány	Raczky *et al*. 1994
Bln-2485	3485	50	Berettyóújfalu-Herpály	Gyulavarsánd	Raczky *et al*. 1994
Bln-2490	3470	60	Berettyóújfalu-Herpály	Ottomány	Raczky *et al*. 1994
GA-22279	3470	25	Vésztő-Mágor	Gyulavarsánd	Previously unpublished
Bln-2492	3455	55	Berettyóújfalu-Herpály	Ottomány	Raczky *et al*. 1994
Bln-2488	3450	45	Berettyóújfalu-Herpály	Gyulavarsánd	Raczky *et al*. 1994

Bln-3973	3440	100	Berettyóújfalu-Herpály	Gyulavarsánd	Raczky *et al*. 1994
Bln-2484	3430	45	Berettyóújfalu-Herpály	Gyulavarsánd	Raczky *et al*. 1994
Bln-2659	3430	50	Berettyóújfalu-Herpály	Gyulavarsánd	Raczky *et al*. 1994
Bln-2499	3400	100	Bakonszeg-Kádárdomb	Ottomány	Raczky *et al*. 1994
Bln-2487	3400	100	Berettyóújfalu-Herpály	Gyulavarsánd	Raczky *et al*. 1994
Bln-2486	3340	60	Berettyóújfalu-Herpály	Gyulavarsánd	Raczky *et al*. 1994
Bln-3982	3270	50	Berettyóújfalu-Herpály	Gyulavarsánd	Raczky *et al*. 1994
Bln-1641	3145	60	Esztár-Fenyvesdomb	Gyulavarsánd	Forenbaher 1993

Table S2. Summary of culture phases used for creation of Table 2 in the main text. Totals exclude isolated burials. The most numerous MBA group is the Gyulavarsánd (n = 125), though it overlaps with the Hajdúsámson (n = 1) and Koszider (n = 5) 'horizons' (David 2002; Fischl *et al*. 2013). In the Körös region, the groups that follow these are the Hajdúbagos (n = 19) and Tumulus (n = 19), both usually considered LBA (Kovács 1970). There are no absolute dates for Hajdúbagos contexts, but the radiocarbon data we have suggest that the majority of the Tumulus material falls 1500–1200 cal BC (Ilon 2005; Fischl *et al*. 2013). Altogether, the Hajdúbagos and Tumulus sites represent a drop from 52 sites per 100 years in the MBA, to 13 sites per 100 years in the early LBA, before dramatically rising in the later LBA to 117 sites per 100 years (Table 2). The first substantial LBA occupation in the Lower Körös Basin is the Gáva group, when settlements again appear in large numbers. Radiocarbon dates for Gáva contexts in north-western Romania support an appearance as early as the fourteenth century (László 2010; Metzner-Nebelsick *et al*. 2010), though 'Classic' Gáva only seems to appear in Hungary by the eleventh century BC (V. Szabó 1996, 1999; Bader 1998).

Phase	Culture	No. of sites
EBA I	Makó	40
	Nyírség	9
	Total	*49*
EBA II	Hatvan	12
	Ottomány	59
	Total	*71*
MBA	Gyulavarsánd	125
	Koszider	5
	Hajdúsámson	1
	Total	*131*
LBA I	Tumulus	19
	Hajdúbagos	19
	Total	*38*
LBA II	Pre-Gáva	3
	Gáva	343
	Urnfield	1
	Total	*347*

Table S3. The body treatment, ceramics and stylistic attributes from dated burials. Form is specified as urn (U), bowl (B), cup (C), and jug (J), and the total refers to number of vessels.

HB	Body treatment	Incising	Tick	Spiral	Boss	Node	Prow	High-arched handle	Channelling	Chevron
3	Inhumation									
4	Scattered cremation			J					J	
6	Cremation urn						U		U	

8	Cremation urn				C	J	U	C	U J		
9	Cremation urn						U		U		
11	Cremation urn			C	C	C	U	C	U C		
13	Cremation urn								U		
14	Cremation urn				U	U	U		U		
15	Cremation urn					U C	U		U		
17	Cremation urn	C		C	C	U	U	C	U		
21	Cremation urn	U		U	U						
26	Cremation urn					U J	U		U J		
27	Cremation urn						U		U		
28	Cremation urn				U	U J	U		U J		U
37	Cremation urn		U	J	U J		U		U J		
42	Cremation urn	B			U B	U			U B		
43	Inhumation				C			C			
45	Cremation urn	J		J	J	J	U		U J		
47	Cremation urn				U						
48	Cremation urn	U J	U	U J	U J	U	U		U J		U J
50	Cremation urn			U	U				U		
52	Inhumation	C			C				C		
54	Cremation urn				U						
55	Scattered cremation	C									
57	Cremation urn								C		
59	Inhumation				C			C			
60	Cremation urn				U		U		U		
62	Cremation urn		U								
65	Cremation urn				J		U		U J		
66	Cremation urn	U B			B	U			B		B
69	Cremation urn						U		U		
	Total	**10**	**3**	**8**	**23**	**14**	**16**	**5**	**32**		**4**

Table S4. Calibrated dates from Békés 103.

HB	from	to	%	μ	σ	median
55	-2460	-2300	68.3	-2370	60	-2370
62	-2340	-2200	68.2	-2290	60	-2290
52	-1880	-1740	68.2	-1800	50	-1800
52	-1880	-1690	68.1	-1780	60	-1770
14	-1690	-1630	68.2	-1670	30	-1660
14	-1690	-1630	68.2	-1670	30	-1660
21	-1690	-1560	68.2	-1630	50	-1630
11	-1620	-1530	68.2	-1580	40	-1570
47	-1610	-1500	68.2	-1550	40	-1550
42	-1610	-1500	68.2	-1550	40	-1550
60	-1610	-1500	68.2	-1540	40	-1540
69	-1530	-1450	68.2	-1500	30	-1500
48	-1510	-1440	68.2	-1480	30	-1480
28	-1500	-1440	68.2	-1470	30	-1470
9	-1500	-1440	68.2	-1470	20	-1470
3	-1500	-1430	68.2	-1460	30	-1460
8	-1500	-1430	68.2	-1460	20	-1460
4	-1500	-1410	68.2	-1450	30	-1450
50	-1500	-1410	68.2	-1450	30	-1440
65	-1500	-1410	68.2	-1450	30	-1440
13	-1450	-1400	68.2	-1420	40	-1420
15	-1450	-1390	68.2	-1410	40	-1420
43	-1440	-1320	68.2	-1390	50	-1410
17	-1430	-1320	68.2	-1380	40	-1390
6	-1430	-1310	68.2	-1370	40	-1380
26	-1430	-1300	68.2	-1370	40	-1380
27	-1420	-1310	68.2	-1370	40	-1380
66	-1420	-1310	68.2	-1360	40	-1370
45	-1420	-1300	68.2	-1360	40	-1350

37	-1390	-1270	68.2	-1320	40	-1320
54	-1290	-1210	68.2	-1250	50	-1250
59	-1270	-1120	68.2	-1200	70	-1200
57	-1110	-1010	68.2	-1060	40	-1060

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