

SUPPLEMENTARY MATERIAL

Restitutio ab initio: direct dating and isotopic evidence to evaluate the proxy reliability of intrusive archaeobotanical remains

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Supplementary Figures	2
Figure S1	2
Figure S2	3
Figure S3	4
Figure S4	5
Figure S5	6
Figure S6	6
Figure S7	7
Figure S8	8
Figure S9	9
Figure S10	9
Figure S11	10
Supplementary Tables	11
Table S1	11
Table S2	12
Table S3	13
Supplementary Texts	15
Text S1: Oltenița–Valea Mare	15
Text S2: Oltenița–Coadă Lupului	16
Supplementary Material: References	17

Supplementary Figures

Figure S1



Figure S1. Location of the points of interest within the Gumelnița site (Romania) (Source: National Cultural Heritage Cartographic Server, <https://map.cimec.ro/Mapserver/?layer=ran&cod=100629.02#>): 1. Chalcolithic tell (Boian? - KGK VI – Cernavoda I?); 2. Early -Mid. Chalcolithic cemetery (Boian - KGK VI graves alongside some Cernavoda I & Early Iron Age pits); 3. Early Middle Age settlement (Dridu culture); 4. Bronze Age settlement (Tei culture); 5. Mid. – Late Chalcolithic cemetery (KGK VI and Cernavoda II culture); 6. Early Middle Age settlement (Dridu culture)

Figure S2

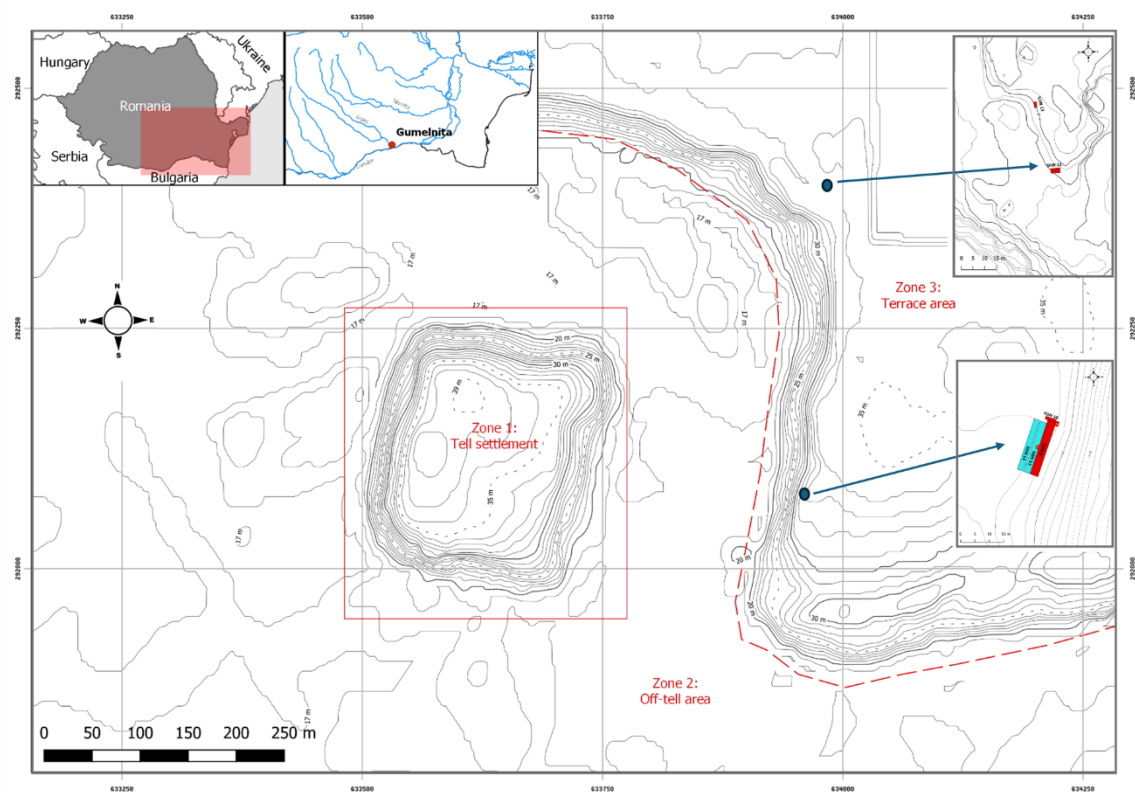


Figure S2. Location of the investigated points of interest within the Gumelnița site (zone 3) in 2018 (red) and 2019 (blue) (after Lazar et al. 2020, modified).

Figure S3

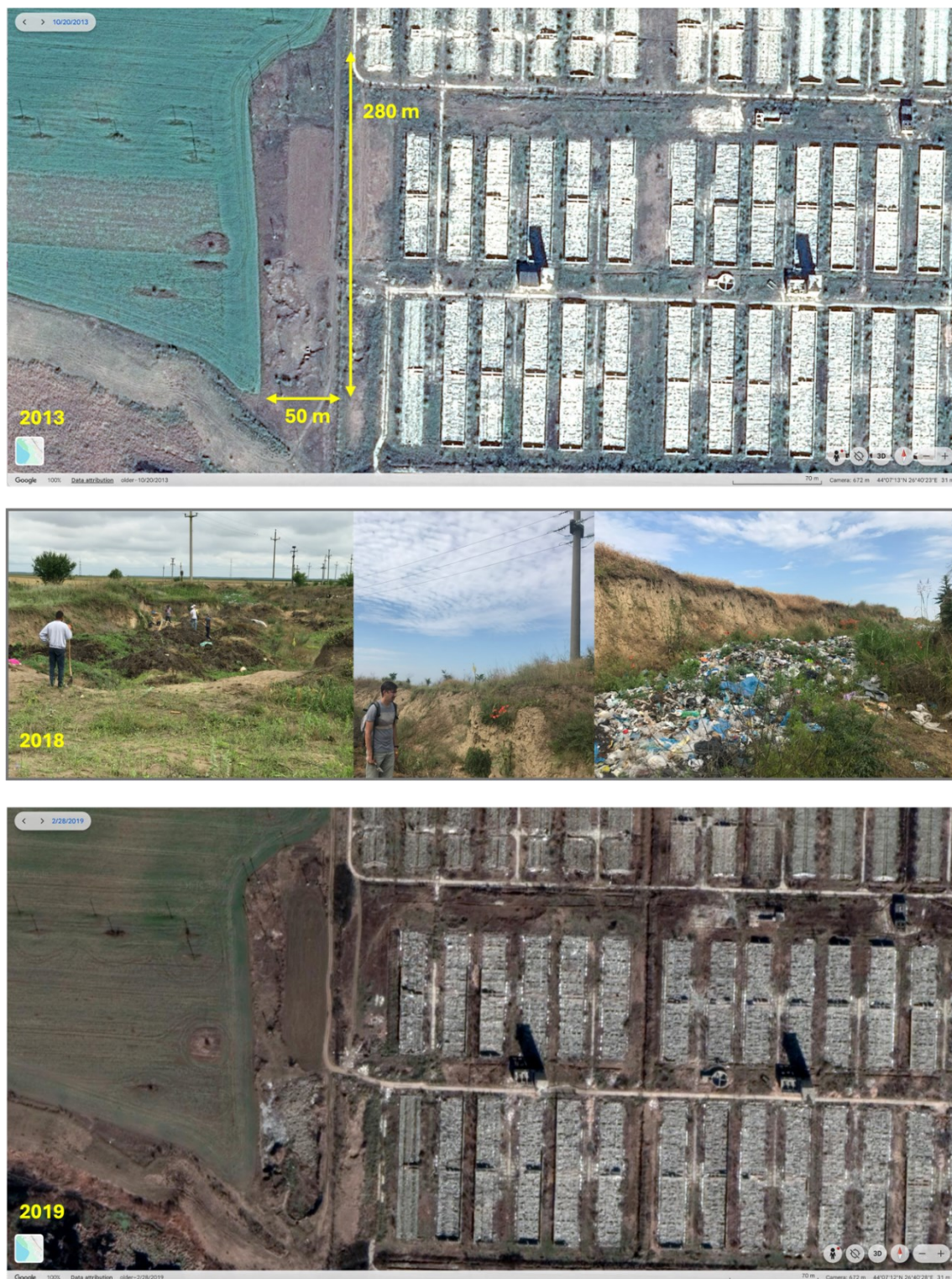


Figure S3. Progressive impact of the illegal excavation in Zone 3 of the Gumelnița site. The earliest satellite record (top; 2013) documents the initial extent of the disturbance. Field photographs taken during our investigations in June 2018 (middle row) show the active pit, which measured approximately 110×30 m at that time, as well as the associated dumping of waste along the exposed archaeological section. The most recent satellite imagery (bottom; 2019) illustrates the continued expansion of the intervention and its cumulative impact on the archaeological deposits. (Source: top & down -<https://earth.google.com/web/search/gumelnita>; middle – Gumelnița Project Archive, photos C. Lazar).

Figure S4



Figure S4. Field photographs documenting our investigation of the illegal intervention pit at the Gumelnița site during the 2018 excavation season (Source: Gumelnița Project Archive, photos C. Lazar).

Figure S5



Figure S5. Grave M10 at the Gumelnița site, from which the millet grains P208, P209 and GUM-122 analysed in this study were recovered (Source: Gumelnița Project Archive, photos O. Frujina, C. Lazar).

Figure S6



Figure S6. Grave M8 at the Gumelnița site, from which the millet grain P207 analysed in this study was recovered (Source: Gumelnița Project Archive, photos O. Frujina, C. Lazar).

Figure S7

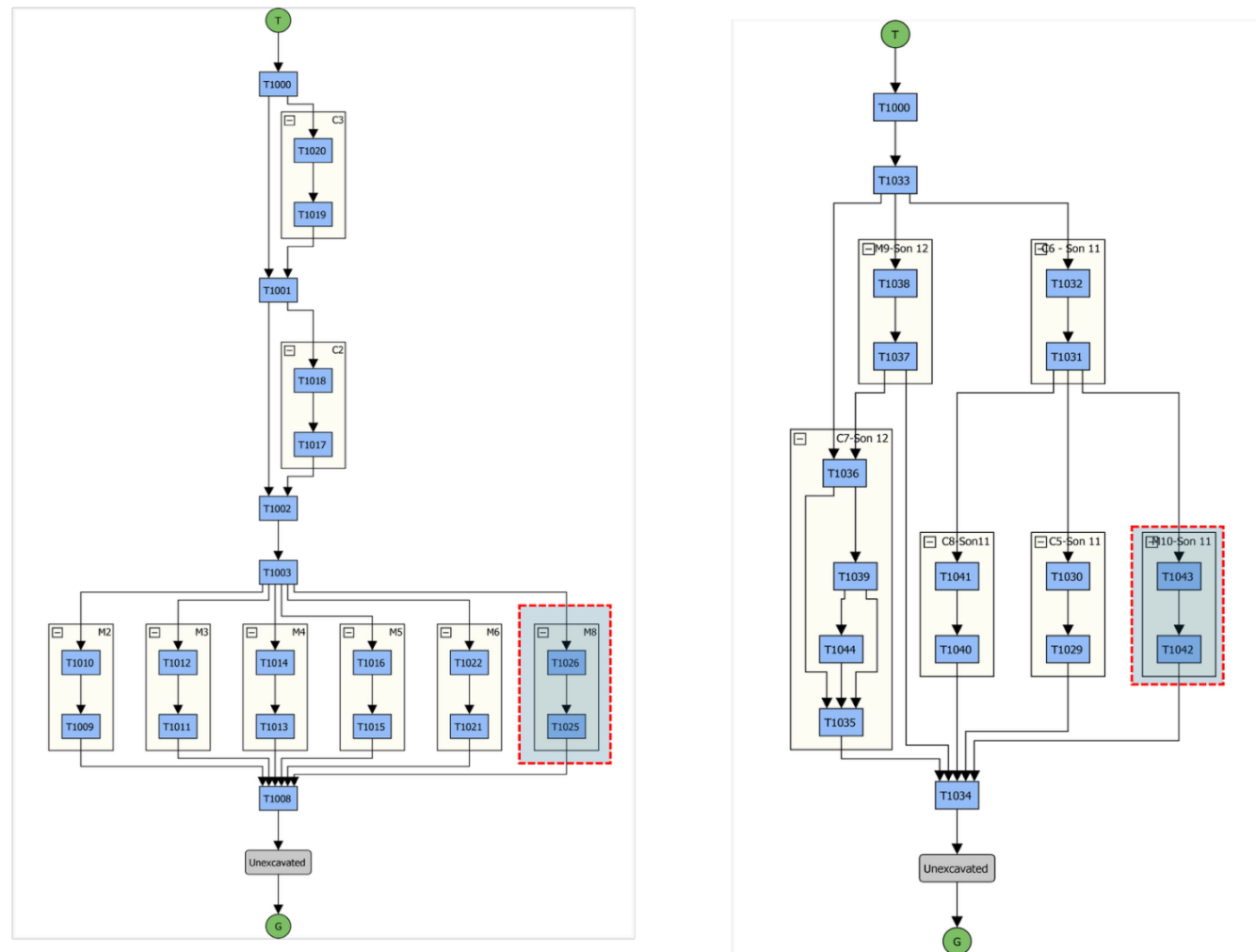


Figure S7. Harris Matrix diagrams illustrating the stratigraphic sequences associated with Grave M8 (left) and Grave M10 (right) at the Gumelnița site. The highlighted units mark the contexts from which the millet grains analysed in this study were recovered after Lazar et al. 2020, modified).

Figure S8

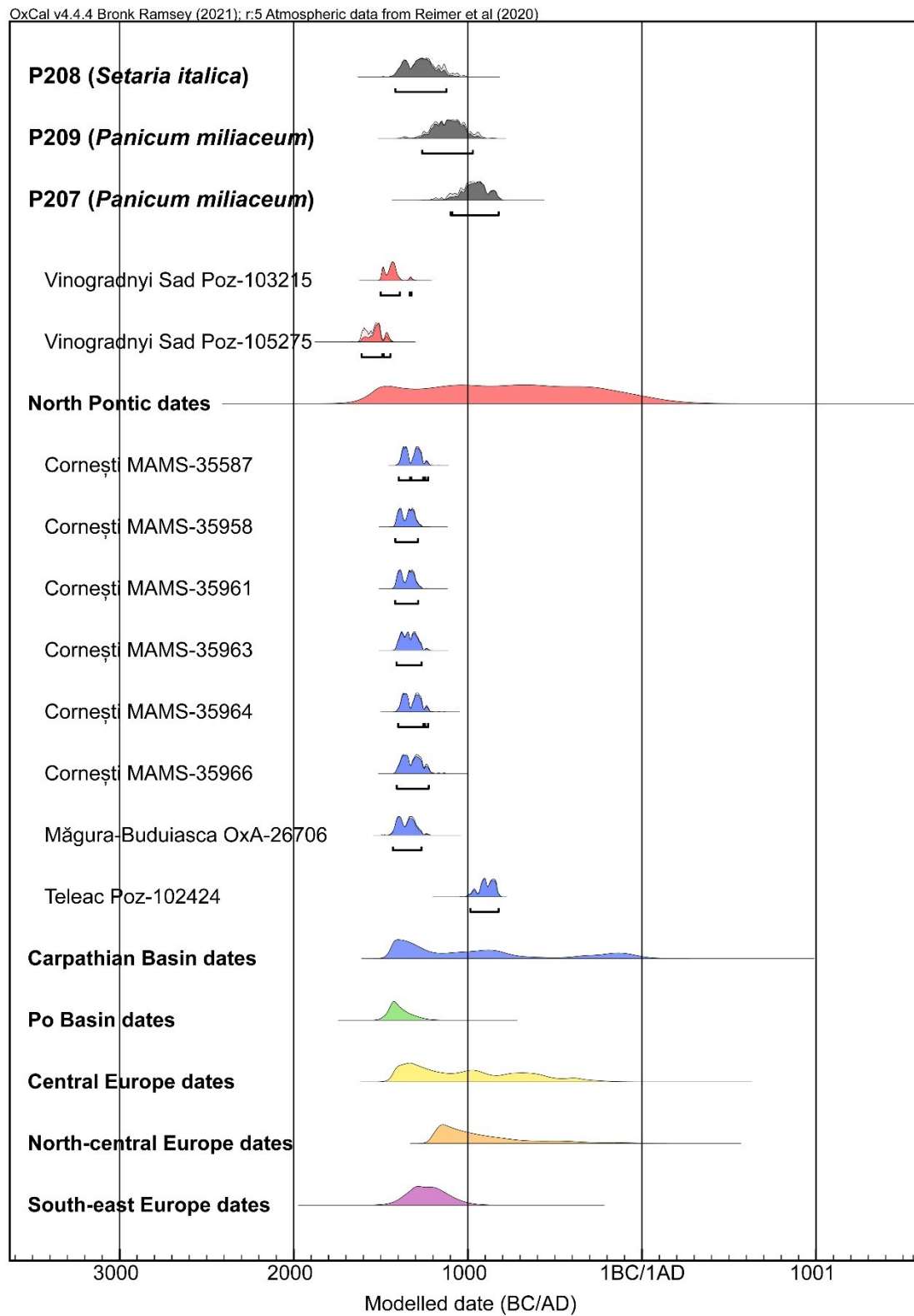


Figure S8. Calibrated radiocarbon dates of the millet grains analysed in this study, shown alongside the earliest known broomcorn millet dates in Europe (from Vinogradnyi Sad) (Dal Corso et al. 2022), the earliest dates from Romania reported by Filipović et al. (2020), and the proposed model for the westward spread of millet into Europe from the same study.

Figure S9

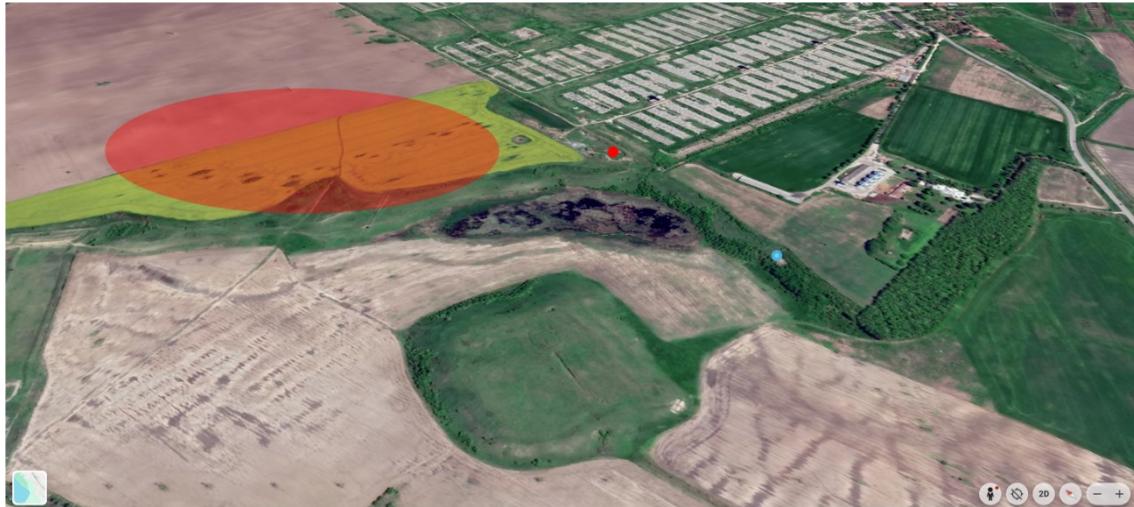


Figure S9. Spatial relationship between the archaeobotanical findings and the area previously attributed to the Tei settlement near the Gumelnița site. The shaded orange zone (left) represents an estimated Bronze Age occupation area, while the red circle indicates the location of the 2018 investigation inside the illegal borrow pit, where Grave M10 was documented. The blue circle corresponds to the main area of necropolis excavations conducted between 2017 and 2024, where Grave M8 was discovered (Map source: Google Earth).

Figure S10



Figure S10. Spatial relationship between the archaeobotanical findings and the surrounding prehistoric landscape near the Gumelnița site. The shaded blue-green zone marks the area previously attributed to the Bronze Age settlement, while the red circle indicates the location of the 2018 investigation inside the illegal borrow pit, where Grave M10 was documented. The blue circle corresponds to the main necropolis excavation area (2017–2024), where Grave M8 was discovered. The yellow circle (left) marks the position of the early Iron Age site at Oltenița–Cooda Lupului, providing a broader chronological and spatial framework for interpreting intrusive Bronze Age and Early Iron Age botanical remains found within the Chalcolithic funerary contexts at Gumelnița (Map source: Google Earth).

Figure S11

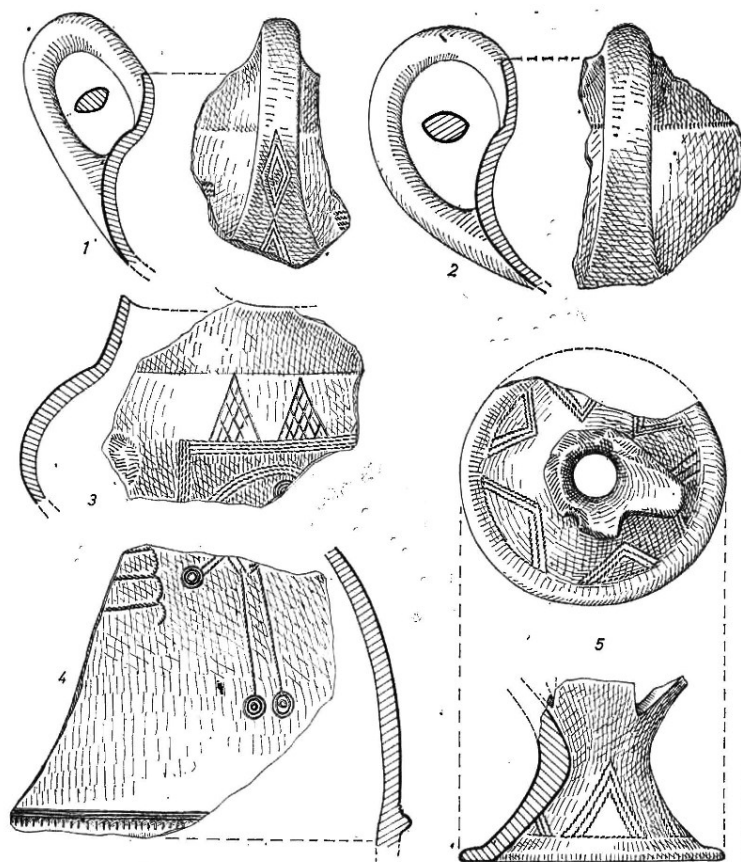


Fig. 47. — Fragmente de vase (1—4) și suport (5) din așezarea de tip Tei, fază IV, de la Oltenița-Valea Mare. 4, „import” de tip Gârla Mare.

Figure S11. Ceramic fragments of the Tei and Gârla Mare cultures recovered from the Late Bronze Age settlement at Oltenița-Valea Mare (after Morintz 1978).

Supplementary Tables

Table S1

Table S1. The radiocarbon dates from Gumelnița tell and cemetery area (Bem 2000; García-Vázquez et al. 2023; Lazăr et al. 2017, 2020; Mattila et al. 2023) calibrated with IntCal20 (Reimer et al. 2020).

<i>No.</i>	<i>Lab.ID</i>	<i>Zone</i>	<i>Feature</i>	<i>Discovery year</i>	<i>Material</i>	<i>Date BP</i>	<i>SD</i>	<i>BC 2σ</i>
1	Beta-430670	3	M1	1962	Human bone	5160	30	4045 – 3943 (88.9%) 3857 – 3816 (6.6%)
2	Poz-52503	3	M3	1962	Human bone	5625	35	4536 - 4362 BC (95.4%)
3	RoAMS-655.4	3	M1-I1	2017	Human bone	5527	43	4454 - 4326 BC (92.1%) 4286 - 4266 BC (3.3%)
4	RoAMS-1321.110	3	M2-I1	2018	Human bone	5437	37	4352 - 4238 BC (93.8%) 4186 - 4176 BC (1.6%)
5	RoAMS-1322.110	3	M2-I2	2018	Human bone	5455	36	4358 - 4244 BC (95.4%)
6	RoAMS-1325.110	3	M3-I2	2018	Human bone	5456	38	4362 - 4240 BC (95.4%)
7	RoAMS-1326.110	3	M4	2018	Human bone	5429	39	4354 - 4230 BC (90.9%) 4194 - 4168 BC (4.6%)
8	RoAMS-1327.110	3	M5	2018	Human bone	5545	37	4452 - 4337 BC (95.4%)
9	RoAMS-1328.110	3	M6	2018	Human bone	5485	38	4444 - 4418 BC (7.5%) 4402 - 4312 BC (59.1%) 4302 - 4251 BC (28.8%)
10	RoAMS-1330.110	3	M8	2018	Human bone	5497	38	4446 - 4318 BC (77.9%) 4295 - 4256 BC (17.6%)
11	RoAMS-1332.110	3	M10	2018	Human bone	5646	36	4548 - 4362 BC (95.4%)
12	RoAMS-5111.1	3	M15	2019	Human bone	5490	36	4444 - 4418 BC (8.9%) 4402 - 4317 BC (63.2%) 4297 - 4254 BC (23.3%)
13	RoAMS-5112.1	3	M16	2019	Human bone	5364	34	4330 - 4280 BC (21.5%) 4274 - 4216 BC (25.4%) 4206 - 4158 BC (22.2%) 4136 - 4054 BC (26.3%)
14	RoAMS-1334.110	3	C6, s.u. T1032	2018	Animal Bone (ovicaprine)	5635	35	5041 - 4836 BC (95.4%)
15	RoAMS-1335.110	3	C7, s.u. T1039	2018	Animal Bone (<i>Bos tarus</i>)	6040	36	4542 - 4436 BC (66.6%) 4430 - 4363 BC (28.9%)
16	Poz-52502	1	M1	1960 (?)	Human bone	5495	35	4444 - 4416 BC (11.1%) 4404 - 4319 BC (66.2%) 4295 - 4256 BC (18.1%)
17	RoAMS-656.4	1	L2, s.u. 1032	2017	Animal Bone (herbivore)	5560	39	4484 - 4480 BC (0.8%) 4456 - 4340 BC (94.6%)
20	RoAMS-657.4	1	C6, s.u. 1031	2017	Animal Bone (herbivore)	5556	41	4487 - 4478 BC (1.4%) 4458 - 4336 BC (94.0%)
21	RoAMS-658.4	1	C2, s.u. 1013	2017	Animal Bone (herbivore)	5582	36	4493 - 4472 BC (5.2%) 4461 - 4346 BC (90.3%)
22	RoAMS-659.4	1	C5, s.u. 1030	2017	Animal Bone (herbivore)	5538	37	4450 - 4334 BC (95.4%)
23	GrN-3025	1	GUMT	n/a	Charcoal	5700	70	4708 - 4440 BC (87.8%) 4424 - 4367 BC (7.6%)
24	GrN-3028	1	GUMT	n/a	Grains	5400	90	4442 - 4420 BC (1.8%) 4396 - 4382 BC (0.9%)

								4370 - 4039 BC (90.7%) 4020 - 3992 BC (2.1%) 4333 - 4224 BC (65.9%) 4200 - 4164 BC (17.4%) 4128 - 4111 BC (2.7%) 4100 - 4060 BC (9.3%)
25	RoAMS-1336.110	1	C9, s.u. 1041	2018	Animal Bone (<i>Bos tarus</i>)	5379	29	
26	RoAMS-1337.110	1	C12, s.u. 1048	2018	Animal Bone (<i>Bos tarus</i>)	5472	29	4362 - 4314 BC (56.4%) 4300 - 4252 BC (39.0%)
27	RoAMS-1616.122	1	C6, s.u. 1031	2017	Seeds	5809	43	4783 - 4745 BC (7.3%) 4731 - 4546 BC (88.1%)
28	RoAMS-1617.122	1	C4, s.u. 1027	2017	Seeds	5660	57	4672 - 4668 BC (0.3%) 4659 - 4636 BC (2.3%) 4616 - 4356 BC (92.8%)
29	RoAMS-1619.122	1	L1, s.u. 1026	2017	Seeds	5552	49	4495 - 4329 BC (95.4%)
30	RoAMS-1622.122	1	L1, s.u. 1026	2017	Seeds	5482	32	4442 - 4421 BC (4.4%) 4392 - 4389 BC (0.3%) 4370 - 4314 BC (60.7%) 4300 - 4252 BC (30.1%)
31	RoAMS-1624.122	3	C7, s.u. T1039	2018	Seeds	5954	37	4936 - 4726 (95.4%)
32	RoAMS-1625.122	1	C6, s.u. 1031	2017	Seeds	5464	38	4439 - 4426 BC (1.6%) 4365 - 4242 BC (93.8%)

Table S2

Table S2. Sediment samples collected from Graves M8 and M10 at Gumelnița. Sed. = sediment; SU = stratigraphic unit; UST = stratigraphic unite terrace; Son = test sondage; Terasa / Terasă = terrace; M8, M10 = graves / burial contexts; L = litres.

No.	Type	Complex/ Feature	Area/ Surface	Grid Square	SU	Quantity	Depth (mstl)
54	Sed.	M8	Son 9	4	T1026	10 L	29.068; 28.814
55	Sed.	M8	Son 9	4	T1026	10 L	29.068; 28.814
56	Sed.	M8	Son 9	4	T1026	10 L	29.068; 28.814
57	Sed.	M8	Son 9	4	T1026	10 L	29.068; 28.814
58	Sed.	M8	Son 9	4	T1026	10 L	29.068; 28.814
59	Sed.	M8	Son 9	4	T1026	10 L	29.068; 28.814
60	Sed.	M8	Son 9	4	T1026	10 L	29.068; 28.814
61	Sed.	M8	Son 9	4	T1026	10 L	29.068; 28.814
62	Sed.	M8	Son 9	4	T1026	10 L	29.068; 28.814
63	Sed.	M8	Son 9	4	T1026	10 L	29.068; 28.814
65	? (unclear: "dru"?)	M8	Son 9	4	T1026	—	29.068; 28.814
70	Sed.	M8	Son 9	4	T1026	10 L	29.068; 28.814
71	Sed.	M8	Son 9	4	T1026	10 L	29.068; 28.814
72	Sed.	M8	Son 9	4	T1026	10 L	29.068; 28.814
103	Sed.	M10	Terasă / Son 11	—	T1043	10 L	32.394; 32.181
104	Sed.	M10	Son 11 / Terasă	—	T1043	10 L	32.384; 32.161
105	Sed.	M10	Son 11 / Terasă	—	T1043	10 L	32.354; 32.181
106	Sed.	M10	Son 11 / Terasă	—	T1043	10 L	32.354; 32.161
107	Sed.	M10	Son 11 / Terasă	—	T1043	10 L	32.354; 32.181
108	Sed.	M10	Son 11 / Terasă	—	T1043	10 L	32.364; 32.161
109	Sed.	M10	Son 11	—	T1043	10 L	32.296; 32.181
110	Sed.	M10	Son 11 / Terasă	—	T1043	10 L	32.339; 32.181
111	Sed.	M10	Son 11 / Terasă	—	T1043	10 L	32.306; 32.181
114	Sed.	M10	Son 11 / Terasă	—	T1069	10 L	32.384; 32.181

Table S3

Table S3. Taxonomical list of macro-botanical remains identified from Gumelnița, 2018 campaign (after Lazar et al. 2020, modified).

Complex/Feature			Total	C7	M5	M6	M7	M8	M9	M10
Stratigraphical unit				suT 1039	suT 1016	suT 1022	suT 1024	usT 1026	suT 1038	suT 1043
Square (□)					10	5 – 6	10	4	4	
Volume of processed sediment (liter)			288	49	32	60	22	20	44	61
Number of samples processed			28	5	3	6	3	2	5	4
Plant concentration per liter (unit/liter)			0.6	1.69	0.12	0.2	0.18	0.2	0.72	0.55
Total number of finds			174	83	4	12	4	4	32	35
Species	Organ	Preservation								
Cereals			76							
Poaceae	caryopse fragment	charred	17	2		3			4	8
Poaceae cf. <i>Bromus</i> sp.	caryopse	charred	1		1					
Poaceae cf. <i>Bromus</i> sp.	caryopse fragment	charred	1						1	
Poaceae cf. <i>Bromus/Stipa</i>	caryopse fragment	charred	1						1	
cf. <i>Bromus</i> sp.	caryopse	charred	3	3						
<i>Stipa</i> sp.	caryopse	charred	2	2						
<i>Setaria italica</i>	caryopse	charred	1							1
Cerealia	caryopse fragment	charred	15	15						
Cerealia cf. <i>Hordeum</i>	caryopse fragment	charred	1			1				
Cerealia cf. <i>Triticum</i>	caryopse fragment	charred	2						2	
<i>Panicum miliaceum</i>	caryopse	charred	3					1		2
cf. <i>Panicum miliaceum</i>	caryopse fragment	charred	1							1
<i>Triticum monococcum</i>	caryopse	charred	3	1					2	
<i>Triticum</i> cf. <i>spelta</i>	caryopse fragment	charred	1	1						
<i>Triticum</i> sp.	caryopse	charred	1	1						
<i>Triticum</i> sp.	caryopse fragment	charred	4			1				3
<i>Hordeum vulgare vulgare</i>	caryopse	charred	1	1						
<i>Hordeum vulgare vulgare</i>	caryopse fragment	charred	1							1
<i>Hordeum vulgare</i> var. <i>nudum</i>	caryopse	charred	3	3						
<i>Hordeum</i> sp.	caryopse	charred	6	1	2				3	
<i>Hordeum</i> sp.	caryopse fragment	charred	7	5						2
cf. <i>Hordeum</i> sp.	caryopse	charred	1	1						
Pulses			5							
Fabaceae	seed fragment	charred	2	1						1
<i>Pisum</i> cf. <i>sativum</i>	seed	charred	2			2				
<i>Vicia ervilia</i>	seed	charred	1	1						
Gathered fruits			6							

<i>Prunus</i> sp.	endocarp fragment	charred	2	1	1					
cf. <i>Prunus</i> sp.	endocarp fragment	charred	4	1					3	
Herbaceous plants			8							
<i>Brassica</i> sp.	seed coat fragment	charred	1						1	
<i>Chenopodium album</i>	seed	charred	3	3						
<i>Galium</i> cf. <i>spurium</i>	seed	charred	3	3						
<i>Persicaria lapathifolia</i>	seed	charred	1	1						
Indetermined macroremains			79							
Indet.	fragment	charred	79	36		5	4	3	15	16

Supplementary Texts

Text S1: Oltenița–Valea Mare

On the terrace adjacent to the Gumelnița tell is documented a Bronze Age settlement (Figures S1 and S12) at Gumelnița–Valea Mare (also known as Oltenița–Valea Mare). It is located on the high terrace opposite the eponymous tell and is extending for roughly 4 ha (Figure S9) from the former firing range area to the vicinity of the Chalcolithic cemetery along the left bank of the Argeș River. The site was only surveyed (field-walks 1958-1960) and only few occasional excavations/test-pits (with minimal data); the surface finds recovered during investigations conducted between 1958 and 1960, including fine-quality globular vessels with short necks and elevated handles decorated with incised or punctuated geometric motifs such as rhombi, triangles, straight-line bands, and spirals, alongside a rare perforated support fragment with successive puncture ornamentation assigned to Tei culture; notably, a large vessel fragment belonging to Gîrla Mare culture indicate its status as an imported item within the Tei horizon (Figure S11) (Leahu 2003; Morintz 1978, 2000). Although the settlement has not yet been systematically investigated, ceramic material recovered through test excavations indicates a flourishing community, characterised by a category of burnished vessels decorated with incised patterns inlaid with a white substance. A bronze sickle found on the Gumelnița tell site may also be attributed to this time span (Șerbănescu 2009).

Site Information

Location	Display on the map of Romania *
RAN Code	100629.07
Name	Așezarea Tei de la Oltenița - Vizavi de Măgura Gumelnița
County	Călărași
Commune	Municipiul Oltenița
City/Town/Village	Oltenița
Place	Vizavi de Măgura Gumelnița
Landmark	Așezarea se află pe terasa înaltă din partea de nord a Măgurii Gumelnița. Așezarea se întinde de-a lungul terasei, din dreptul Poligonului, până aproape de necropola neolitică, pe malul stâng al râului Argeș.
Hydrographic landmark - name	Argeș
Hydrographic landmark - type	râu
Geomorphology	terasă
Site Class	locuire
Site Type	așezare
Date of discovery	1958 – 1960
Site Surface	4 ha
Ownership	privată
Last record update	12.04.2021

Finds

Class/ Type	Period (Date)	Culture/ Cultural phase	Documentary attestation	Description/ Notes	LMI Code
așezare deschisă	Epoca bronzului mijlociu	Tei / III-IV			

Figure S12. Site information. Source: <https://ran.cimec.ro/sel.asp?codran=100629.07&Lang=EN>

Text S2: Oltenița–Coadă Lupului

On the low terrace known as Coadă Lupului, approximately 3.5 km northeast of Oltenița and situated west of the Bucharest–Oltenița railway line along the right bank of the Argeș River, lies the multi-layered archaeological site of Oltenița–Coadă Lupului (RAN 100629.03; CL-I-s-B-14565) (Figure S13). Occupying roughly 0.5 ha and positioned on a gently protruding terrace ridge, the area has been heavily impacted by past clay-extraction pits and later by the town's refuse deposit, conditions that have severely damaged the archaeological record.

Rescue excavations, surveys, and field walks carried out in 1960–2017, which reached depths of up to 1.80 m, exposed a complex stratigraphic sequence extending from the Eneolithic to the medieval period. The Eneolithic Gumelnița occupation is marked by a 0.30–0.50 m thick layer with hearths, ceramics, and flint and bone implements, while particularly noteworthy are the Basarabi-period Hallstatt materials, whose presence confirms a clear episode of early Iron Age activity on the terrace. The sequence further includes a substantial Getic La Tène layer of roughly 0.70 m, accompanied by three Sarmatian graves from the 2nd–3rd century AD, as well as isolated Roman and early medieval Dridu finds. Although the site remains only partially investigated and has suffered severe disturbance, the available evidence from surface surveys and limited rescue trenches demonstrates repeated, multi-period reuse of this terrace along the Argeș River (Morintz and Ionescu 1968; Șerbănescu 2009).

Site Information					
Location Display on the map of Romania *					
RAN Code 100629.03					
LMI Code (List of Historic Monuments) CL-I-s-B-14565					
Name Situl arheologic de la Oltenița - Coadă Lupului					
County Călărași					
Commune Municipiul Oltenița					
City/Town/Village Oltenița					
Place Coadă Lupului					
Place, other names Groapa de gunoi a orașului					
Landmark Așezarea se află la 3,5 km nord-est de Oltenița, în stânga căii ferate București–Oltenița, pe un bot de terasă joasă, pe malul drept al râului Argeș.					
Hydrographic landmark - name Argeș					
Hydrographic landmark - type râu					
Geomorphology terasă					
Site Class locuire; descoperire funerară					
Site Type așezare; necropolă					
Notes Situl a fost distrus în bună parte de carierele de lut și apoi a fost suprapus de groapa de gunoi a orașului. În anul 1960 aici s-au făcut săpături arheologice de salvare. Secțiunile trasate au ajuns până la 1,80 m adâncime.					
Date of discovery 1960					
Site Surface 8000 mp					
State of preservation grav afectat / 23.06.2009					
Last record update 14.01.2021					
Finds					
Class/Type	Period (Date)	Culture/ Cultural phase	Documentary attestation	Description/ Notes	LMI Code
Așezare	Neolitic	Bolan / Vidra		Strat descoperit deasupra pământului viu, la circa 1,50 m adâncime.	
Locuire	Hallstatt	Basarabi		Epocă atestată de câteva fragmente ceramice sporadice.	
Așezare	La Tène (sec. II-I a.Chr.)	getică		Strat gros de 0,70 cm.	
necropolă	La Tène târziu (sec. II - III)	sarmatică		Au fost cercetate trei morminte sarmatice.	
așezare	Eneolitic	Gumelnița		Strat gros de 0,30–0,50 cm în care s-au găsit vetre, fragmente ceramice unelte de silex și os.	
Locuire	Epoca romană			Au fost descoperite câteva fragmente din epoca romană.	
așezare	Epoca medievală timpurie	Dridu			

Figure S13. Site information. Source: <https://ran.cimec.ro/sel.asp?codran=100629.03&Lang=EN>

Supplementary Material: References

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