ANTROPOLOŠKA ANALIZA SEŽGANIH ČLOVEŠKIH KOSTI IZ GOMIL STAREJŠE ŽELEZNE DOBE V OKOLICI POŠTELE

Tamara Leskovar

Med leti 1989 in 2006 so bile v okolici utrjene naselbine na Pošteli izkopane tri gomile iz časa starejše železne dobe: Velika gomila nad Razvanjem ter gomili 13 in 14 v Pivoli. V nadaljevanju predstavljamo antropološke analize žganih posmrtnih ostankov iz grobov teh gomil.

Žganina iz Velike gomile nad Razvanjem je bila le deloma odkrita v primarni legi. Gomila je bila namreč v preteklosti izropana, žganina pa pri tem raznesena vse do površinske plasti. V grobnici sta bili odkriti dve ločeni zgostitvi žganih kosti, ena v njenem zahodnem in ena v vzhodnem delu.[1]

V gomili 13 v Pivoli, ki je bila prav tako izropana, je bila žganina odkrita na dveh ločenih mestih na dnu grobne kamre[2], v gomili 14 pa na treh mestih na kamnitem tlaku grobne kamre[3].

METODOLOŠKI POSTOPKI

Iz grobov zbrana žganina je bila očiščena in analizirana po uveljavljenih postopkih.[4] Človeške kosti so bile ločene od živalskih in z uporabo sit z odprtinami velikosti 10 mm, 5 mm in 2 mm razdeljene v štiri velikostne razrede (> 10 mm, 10–5 mm, 5–2 mm in < 2 mm). Izmerjeni sta bili največja ohranjena velikost odlomkov in določena skupna teža vsakega izmed velikostnih razredov. Odlomki kosti so bili nato razvrščeni v podrazrede glede na pripadnost skeletnim elementom (lobanja, rebra, nadlahtnica, stegnenica itn.). Če skeletnega elementa ni bilo mogoče natančno določiti, so bili odlomki uvrščeni med dolge kosti, kratke kosti ali sklepne površine, v primeru popolne neprepoznavnosti pa med nedoločljive. Vsak od podrazredov je bil tudi stehtan. Na osnovi primerjave s težo celotnega zbira kosti je bila izračunana zastopanost vsakega velikostnega razreda

1 Glej tu Strmčnik Gulič, Kajzer, Kramberger.
2 Teržan, Črešnar, Kramberger.
3 Glej tu Strmčnik Gulič, Teržan.
4 McKinley 2004; Schultz et al. 2008.

ANTHROPOLOGICAL ANALYSIS OF THE CREMATED HUMAN REMAINS FROM THE EARLY IRON AGE BURIAL MOUNDS NEAR POŠTELA

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Between 1989 and 2006, three Early Iron Age burial mounds were excavated near the fortified settlement of Poštela: Velika gomila above Razvanje and Mounds 13 and 14 at Pivola. In this paper, we present anthropological analyses of the cremated skeletal remains from the graves documented in these mounds.

Not all of the burned remains from Velika gomila above Razvanje were discovered in their original position. Given that the mound was looted in the past, burned remains were moved all the way to the surface layer. In the burial chamber, two separate concentrations of burnt bones were discovered; one in its western and one in its eastern part.[1]

In Mound 13 at Pivola, which was also looted, the burnt skeletal remains were found in two different places at the bottom of the burial chamber[2], and in Mound 14 in three different locations on the stone pavement of the burial chamber[3].

METHODOLOGY

Cremains collected from the graves were cleaned and analysed according to the established procedures.[4] By employing sieves with 10 mm, 5 mm and 2 mm openings, human bones were separated from animal bones and classified into four size classes (> 10 mm; 10–5 mm; 5–2 mm; and <2 mm). The maximum size of the preserved fragments was measured and the total weight of each size class determined. The bone fragments were then divided into subclasses according to their affiliation with distinct skeletal elements (e.g. skull, ribs, humerus, femur, etc.). When the affiliation was impossible to ascertain, the fragments were classified as long bones; short bones; joint surfaces; or, where identification was not possible, as indefinable bones. Each of the subclasses was also weighed. Based on the weight of the total bone collection from each grave, the representation of each

1 See here Strmčnik Gulič, Kajzer, Kramberger.
2 See here Teržan, Črešnar, Kramberger.
3 See here Strmčnik Gulič, Teržan.
4 McKinley 2004; Schultz et al. 2008.

Razmerje / Ratio	Pomen / Significance	Izračun / Calculation	Referenca / Reference
API	Vsebnost karbonatov tipa A / Amount of Type A Carbonates	~1540 cm^{-1} / ~605 cm^{-1}	Sponheimer, Lee-Thorp 1999
BPI	Vsebnost karbonatov tipa B / Amount of Type B Carbonates	~1415 cm^{-1} / ~605 cm^{-1}	LeGeros, LeGeros 1983
SF	Faktor cepljenja / Splitting factor	(~605 cm^{-1} + ~565 cm^{-1}) / ~590 cm^{-1}	Weiner, Bar-Yosef 1990
C/C	Razmerje med vsemi karbonati in karbonati tipa B / Ratio between all the Carbonates and Type B Carbonates	~1450 cm^{-1}/ ~1415 cm^{-1}	Thompson et al. 2009
AmI/P	Vsebnost organskih snovi (predvsem kolagena) / Amount of organic matter (mainly collagen)	~1650 cm^{-1}/ ~1020 cm^{-1}	Trueman et al. 2004; Lebon et al. 2016
CN/P	Vsebnost cianamidov / Amount of cyanamide	~2015 cm^{-1}/ ~600 cm^{-1}	Snoeck et al. 2014

Slika 1. Izbrana razmerja med vrhovi spektrov, pridobljenimi z ATR-FTIR spektroskopijo, način izračuna in pomen razmerja.
Figure 1. Chosen ratios of spectral peaks obtained with the ATR-FTIR spectroscopy, calculation formulae and the meaning of the select ratios.

in podrazreda. Izračunana sta bila odstotek kosti v posameznih plasteh znotraj grobnice oz. gomile ter pripadnost podrazredov določeni plasti.

Vsi odlomki so bili makroskopsko pregledani in izmerjeni. Zabeležene so bile značilnosti za oceno spola in starosti, morebitne patološke spremembe ter debelina ohranjenih lobanjskih kosti. Opisani so bili barva zunanje, notranje in prelomne površine odlomkov ter vzorci razpok.

Na odlomku kosti iz gomile nad Razvanjem so bile po uveljavljenih metodah[5] pripravljene in pod mikroskopom analizirane histološke rezine preseka kosti. Histološke analize na kosteh iz Pivole zaradi preslabe ohranjenosti niso bile možne.

1–2 cm velika odlomka kortikalne kosti stegnenice sta bila utrjena z epoksi smolo ter z diamantno žago z vodnim hlajenjem razrezana na rezine debeline 100 µm. Rezine so bile nato zbrušene do debeline, ki je dovoljevala presevanje svetlobe.[6] Histološka analiza je bila opravljena z uporabo svetlobnega mikroskopa s presevno in polarizacijsko svetlobo ter z uporabo 1/4 lambda ploščice pri 100-kratni povečavi. Starost osebe ob smrti je bila ocenjena po metodah Hummel in Schutkowski ter Ericksen.[7] Tako so bili na zunanjem, osrednjem in notranjem delu kortikalne kosti določeni, fotografirani in opisani najbolje ohranjeni deli mikrostrukture. Na vsakem izmed fotografiranih delov je bilo zamejeno območje velikosti 1 mm^2, znotraj katerega so bili opredeljeni različni deli mikrostrukture kosti. Pridobljeni

[5] Wighton et al. 2012, 21–36; Valentine, Piper 2012, 37–50.
[6] Za pomoč pri pripravi histoloških rezin se najlepše zahvaljujemo prof. dr. Giseli Grupe in njeni ekipi iz Fakultete za Biologijo Univerze Ludwig-Maximiliana v Münchnu, kjer sem gostovala s pomočjo štipendije DAAD.
[7] Hummel, Schutkowski 1993, 111–123; Ericksen 1991, 171–179.

size class and subclass was calculated. The percentage of bones in each layer within the chamber or mound, and the association of subclasses with a particular layer were, likewise, calculated.

All fragments were macroscopically examined and measured and the characteristics used to assess sex and age at death, possible pathological changes, and the thickness of the preserved cranial bones were noted. The crack patterns and the colour of the outer, inner and fracture surfaces of the fragments were also described.

Histological sections of a cross section from a bone fragment from the mound Velika gomila above Razvanje were prepared and analysed under a microscope according to the established methodology[5]. Due to their poor preservation, histological analyses of the bones from Pivola were not undertaken.

Fragments of 1–2 cm of the femoral cortical bone from Velika gomila were hardened with epoxy resin and cut into 100 µm slices with a water-cooled diamond saw. The slices were then ground until they became translucent (app. 50–60 µm).[6] Histological analysis was performed using a transmitting light microscope and a range of light sources, including plane polarised and crossed polarised light at 100x magnification. In addition, a 1/4 lambda plate at 100x magnification was employed to examine the bone's crystalline structure. The age at death was estimated using the methods of Hummel and Schutkowski and Ericksen:[7] the best-preserved parts of the microstructure were identified, photographed and described for the outer, central and inner part of the cortex. On each of the photographed parts, a 1 mm^2 area was delineated, within which different parts of the bone microstructure were identified. The obtained data were entered into regression equations for age estimation.

Spectroscopic analyses were performed on two samples to determine the chemical composition of the bones and estimate their exposure to high temperatures. A small fragment of cremated long bone from Mound 13 from Pivola and another from Velika gomila above Razvanje was scanned with an ATR-FTIR[8] spectrometer. Each sample was scanned 64 times with a resolution of 4 cm^{-1} in the range

[5] Wighton *et al.* 2012, 21–36; Valentine, Piper 2012, 37–50.
[6] For their help with the histological analysis, I would like to thank prof. dr. Giseli Grupe and her team from the Faculty of Biology of the Ludwig-Maximiliana University in Munich, where I was a guest researcher during my DAAD scholarship.
[7] Hummel, Schutkowski 1993, 111–123; Ericksen 1991, 171–179.
[8] Attenuated Total Reflection Fourier Transform Infrared.

podatki so bili vneseni v regresivne enačbe za oceno starosti.

Na dveh vzorcih so bile opravljene tudi spektroskopske analize za določitev kemične sestave kosti in za oceno njihove izpostavitve visokim temperaturam. Manjši odlomek sežgane dolge kosti iz gomile 13 iz Pivole in iz Velike gomile nad Razvanjem je bil skeniran z ATR-FTIR[8] spektrometrom. Vsak vzorec je bil z resolucijo 4 cm^{-1} v območju med 400 in 4000 cm^{-1} skeniran 64-krat. Pridobljeni spektri so bili nadalje obdelani in preračunani glede na najvišji vrh (~1020 cm^{-1}). Na podlagi pregleda drugih raziskav so bili zbrana in izračunana najpogosteje uporabljena razmerja med vrhovi za analize žganih kosti z uporabo FTIR spektroskopije (*sl. 1*). Opravljene so bile primerjave s podatki za svežo kost,[9] eksperimentalno sežganimi živalskimi kostmi[10] ter medsebojne primerjave vzorcev glede na arheološki kontekst.

Na osnovi opravljenih analiz in makroskopskih pregledov[11] je bilo določeno minimalno število posameznikov (MNI) v posameznem zbiru žganine. Kadar je ohranjenost odlomkov dovoljevala, je bila ocenjena starost osebe ob smrti. Zaradi slabe ohranjenosti kosti ni bilo mogoče oceniti spola in telesne višine nobene od oseb. Prav tako ni bilo opaziti znakov patoloških sprememb.

S pregledom barv odlomkov kosti je bila ocenjena višina temperature, ki so ji bile kosti izpostavljene ob sežigu. Pri tem velja opozoriti, da barva omogoča le približno oceno temperature. Četudi drži, da z naraščanjem temperature kost spremeni barvo iz rumene v temno rjavo, črno, modro/sivo in belo, na potek sprememb vplivajo različni dejavniki, kot so denimo čas izpostavljenosti, prisotnost drugih organskih ali anorganskih snovi, prisotnost/odsotnost mehkega tkiva in dostopnost kisika.[12] Ocena temperature je bila zato dopolnjena z vizualno analizo histoloških preparatov in ATR-FTIR spektrov ter njihovo primerjavo z eksperimentalno sežganimi vzorci.

Vzorci razpok na kosteh so bili uporabljeni za razlago procesa žganja ter sprememb na kosteh kot posledice izpostavljenosti visokim temperaturam. Opozoriti velja, da mnenja o pomenu vzorcev razpok niso povsem usklajena in standardizirana[13] ter moramo njihove razlage razumeti z določeno mero previdnosti.

between 400 and 4000 cm^{-1}. The spectra obtained were processed and normalised to the highest peak (~ 1020 cm^{-1}). Based on a review of other studies, the most frequently used peak ratios for the analysis of cremated bone using FTIR spectroscopy were determined and calculated (*fig. 1*). Comparisons were made with data for fresh bone;[9] experimentally burned animal bones;[10] and samples from different archaeological contexts.

Based on the selected analyses and macroscopic studies,[11] the minimum number of individuals (MNI) in each collection of cremated remains was determined. Where the preservation of the remains permitted, the age at death was estimated. Due to the poor preservation of the bones, it was not possible to assess the sex and stature of any of the individuals. No signs of pathological changes were observed.

By examining the colours of the bone fragments, the temperature to which the bones were exposed during cremation was estimated. It should be noted that the colour allows only an approximate estimate of the temperature. While the colour of the bone does, indeed, change with increasing temperature from yellow to dark brown, black, blue/grey and white, the progression of the change is influenced by various factors such as exposure time, presence of other organic or inorganic substances, presence/absence of soft tissue and availability of oxygen.[12] The temperature assessment was, therefore, supplemented by the visual analysis of the histological samples and the ATR-FTIR spectra, and their comparison with the experimentally burned samples.

Crack patterns on bones were used to explain the burning process and bone changes consequent to their exposure to high temperatures. Considering the subjective nature of the meaning of crack patterns and that the analyses are not fully standardised,[13] their interpretation must be approached with some caution.

8 Attenuated Total Reflection Fourier Transform Infrared.

9 Leskovar et al. 2019.

10 Thompson et al. 2013; Snoeck et al. 2014.

11 McKinley 2000, 408–409, 410.

12 Mays, 1998, 217; McKinley 2004, 11; Walker et al. 2008, 132–133; Shipman et al. 1984, 307–325; Mayne Correia 1997, 275–293; McKinley 2000, 404.

13 Mayne Correia 1997, 275–293; McKinley 2000, 405; Symes et al. 2008, 42–45.

9 Leskovar *et al.* 2019.

10 Thompson *et al.* 2013; Snoeck *et al.* 2014.

11 McKinley 2000, 408–409, 410.

12 Mays, 1998, 217; McKinley 2004, 11; Walker *et al.* 2008, 132–133; Shipman *et al.* 1984, 307–325; Mayne Correia 1997, 275–293; McKinley 2000, 404.

13 Mayne Correia 1997, 275–293; McKinley 2000, 405; Symes *et al.* 2008, 42–45.

Slika 2. Povzetek rezultatov analiz.
Figure 2. Summary of the analysis results.

Najdišče / Site	Gomila / Tumulus	Teža / Weight (g)	MNI	Starost / Age	Spol / Sex	Temp. žganja / Temp. of firing	Živali / Animals
Razvanje	Velika gomila	117,3	1	odrasel / adult, 30–50 let / years	nedoloč. / unident.	> 900 °C	konj / a horse[14]
Pivola	gomila 13 / Mound 13	120	1	odrasel / adult, <30 let / years	nedoloč. / unident.	300–700 °C, ~800 °C	vrsta nedoloč. / sp. indet.
Pivola	gomila 14 / Mound 14	219	1	odrasel / adult	nedoloč. / unident.	300–700 °C, ~800 °C	

Slika 3. Teža ohranjenih žganih delov skeleta iz Razvanja in Pivole.
Figure 3. The weight of the skeletal elements from Razvanje and Pivola.

Gomila / Tumulus	Kost / Bone	Teža / Weight (g)	%
Razvanje			
Velika gomila	*lobanja / cranium*	9	7,7
	vretence / vertebra	1	0,9
	nadlahtnica / humerus	7,2	6,1
	koželjnica / radius	1,1	0,9
	podlahtnica / ulna	6,7	5,7
	stegnenica / femur	6,3	5,4
	golenica / tibia	1,2	1
	dolga kost / long bone	71,6	61
	nedoločljivo / unidentified	13,2	11,3
Pivola			
Gomila 13	*lobanja / cranium*	7	5,8
	rebro / rib	0,5	0,4
	sklepna površina / articular surface	1,5	1,25
	dolga kost / long bone	33,5	27,9
	nedoločljivo / unidentified	77,5	64,6
Gomila 14	*lobanja / cranium*	8	3,7
	koželjnica / radius	2	0,9
	kolčnici / os coxae	2	0,9
	sklepna površina / articular surface	1	0,5
	dolga kost / long bone	9	4,1
	nedoločljivo / unidentified	197	89,9

REZULTATI IN UGOTOVITVE

Izvidi analiz so povzeti na *sl. 2* in *3*. Analizirane kosti so bile večinoma bele barve. Na nekaterih notranjih in prelomnih površinah so bili opazni svetlo in temno sivi, redko tudi modri in črni odtenki. Izjemoma so bile zunanje površine obarvane sivo ali rdeče-rjavo. Modri, sivi in črni odtenki so bili zabeleženi predvsem na kosteh iz gomil v Pivoli. Na kosteh so bile vidne prečne, vzdolžne, mrežaste in U-oblikovane razpoke, izrazito upognjeni odlomki pa so bili zabeleženi med kostmi iz gomile nad Razvanjem.

Histološka analiza kosti iz gomile nad Razvanjem kaže deloma ohranjeno mikrostrukturo. Prepoznavni so primarni osteoni, sekundarni osteoni s Haversonovimi kanali, lakune in lamelarna kortikalna kost (*sl. 4*). Pod polarizacijsko svetlobo je vidno, da dvolomnost ni ohranjena (*sl. 4B* in *4C*). S histološko analizo in uporabo regresivnih enačb je bila starost

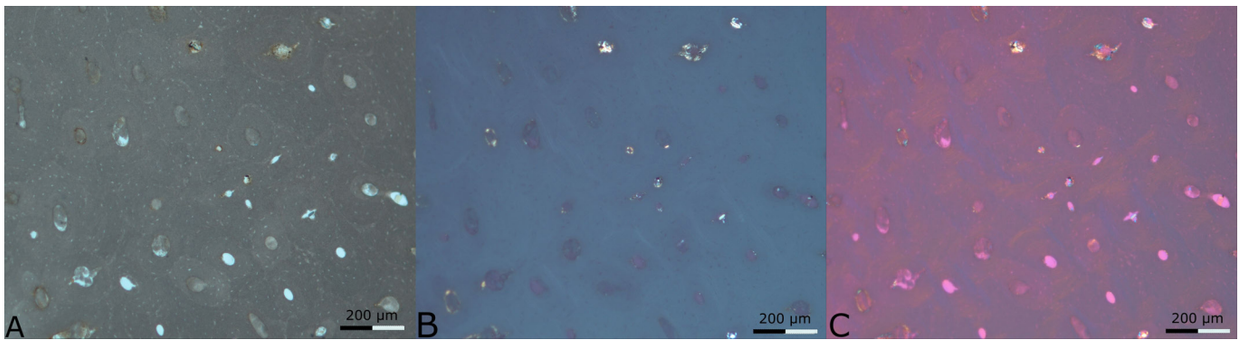
[14] Glej tu Toškan; Thomas, Sežgani človeški ostanki.

RESULTS AND DISCUSSION

The results of the analyses are summarised in *figs. 2* and *3*. The analysed bones were predominantly white. Light and dark shades of grey, and rarely blue and black, were observed on some inner surfaces and fractures. In only a few instances were the outer surfaces grey or reddish-brown. Blue, grey and black shades were mainly observed on the bones from the Pivola mounds. Transverse, longitudinal, reticular, and U-shaped cracks were visible on the bones from all three locations, while distinctly curved fragments were identified only among the bones from Velika gomila above Razvanje.

Histological analysis of the bone from Velika gomila above Razvanje showed a partially preserved microstructure. Primary osteons, secondary osteons with Haversian canals, lacunae and lamellar cortical bone were all recognizable (*fig. 4*). The birefringence of the bone was not preserved, as observed under

[14] See here Toškan; Thomas, Cremated human remains.



Slika 4. Mikrografi preseka stegnenice iz Velike Gomile nad Razvanjem (100× povečava). **A** – Mikrograf pod presevno svetlobo, ki kaže na dobro ohranjeno mikrostrukturo kosti. **B** – Mikrograf pod polarizacijsko svetlobo, kjer odsotnost temnih in svetlih odtenkov kaže na izgubo dvolomnosti. **C** – Mikrograf pod polarizacijsko svetlobo in z uporabo lambda filtra, kjer odsotnost različnih barv kaže na urejeno in poenoteno kristalinsko strukturo različnih delov mikrostrukture kosti.

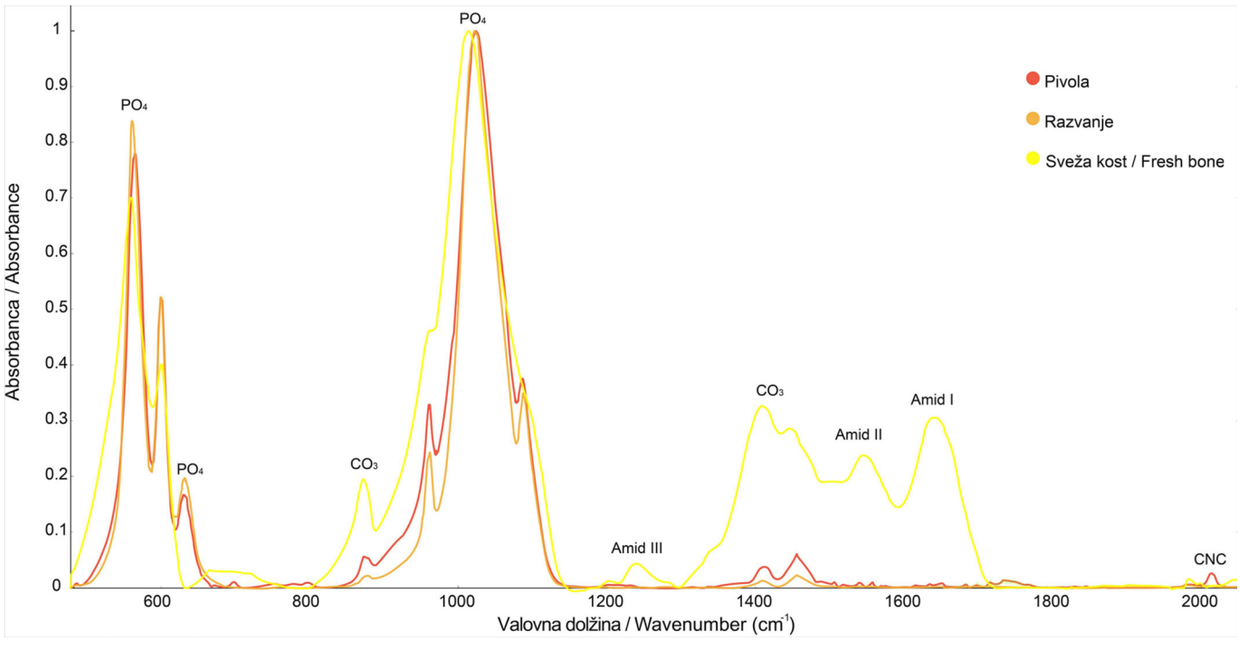
Figure 4. Micrographs of the femur cross-section from Velika gomila above Razvanje (100× magnification). **A** – Micrograph under the plane polarised light, showing well-preserved bone microstructure. **B** – Micrograph under the crossed polarised light, lacking dark and bright hues, indicating the loss of birefringence. **C** – Micrograph under crossed polarised light with lambda filter applied. The lack of different colours indicates organised and unified crystalline structure of different microstructural parts of the bone.

osebe, pokopane v gomili nad Razvanjem, ocenjena na 30–50 let.

Spektri vzorcev sežganih kosti kažejo izgubo organskih snovi oz. kolagena v kosteh ter spremembe v strukturi minerala (*sl. 5)*. Vsi vrhovi amidov (I–III) na območju med ~1150 in ~1700 cm^{-1}, ki v kosti večinoma predstavljajo kolagen, so z razgradnjo organskih snovi povsem izginili. Ohranili so se le v tem delu spektra zaznavni vrhovi karbonata (CO_3), vidni pri ~1415 in 1460 cm^{-1}. Opazno spremenjeni so tudi vrhovi fosfata (PO_4) in karbonata (CO_3), ki so zaradi izgube nekaterih komponent bodisi ožji in ostrejši (~480–620 cm^{-1}, ~900–1150 cm^{-1}) bodisi so skoraj povsem izginili (~870 cm^{-1}, ~1300–1500 cm^{-1}). Z izpostavitvijo visokim temperaturam je v kosteh prišlo do sprememb minerala, zaradi česar sta se pojavila nova vrhova fosfata (PO_4) pri ~630 cm^{-1}

crossed polarizing light, indicating that temperatures of some 800 °C were achieved (*figs. 4B* and *4C*). Based on the histological analysis and the use of regression equations, the age at death of the individual buried in Velika gomila was estimated to be 30–50 years.

The spectra of burned bones indicated the loss of their organic matter, namely the collagen, and changes in their mineral structure (*fig. 5*). All the amide peaks (I-III) in the range between ~1150 and ~1700 cm^{-1}, which mostly represent the bone's collagen, had completely disappeared with the degradation of organic matter. In this part of the spectrum, the only detectable peaks were those of the carbonates (CO_3), visible at ~1415 and ~1460 cm^{-1}. The peaks of the phosphates (PO_4) and carbonates (CO_3) were also noticeably altered: they were either narrower and



Slika 5. ATR-FTIR spektri sveže kosti ter vzorcev kosti iz obravnavanih grobov.
Figure 5. The ATR-FTIR spectra of fresh bone and bone samples from the analysed graves.

in cianamida (CN/P) pri ~2010 cm^{-1}, slednji jasneje pri vzorcu iz Pivole. V spektru vidne spremembe potrjujejo tudi izračunana razmerja, saj je količina organskih snovi in karbonatov, predvsem karbonatov tipa B, jasno upadla, faktor cepljenja, ki odraža kristaliničnost in urejenost mineralne mreže, pa se je močno dvignil (*sl. 6*). Vsebnosti cianamida so kljub opaznim vrhovom nizke, pod 0,25, kar kaže na njihovo komaj zaznavno prisotnost.[15]

Slika 6. Razmerja (glej *sl. 1*), izračunana na podlagi višine vrhov spektrov.
Figure 6. Selected ratios (see *fig. 1*), calculated based on the spectral peak heights.

Vzorec / Sample	API	BPI	SF	C/C	AmI/P	CN/P
Pivola	0,017	0,07	5,89	1,60	0,009	0,05
Razvanje	0,004	0,02	6,55	1,85	0,002	0,01
Sveža kost / Fresh bone	0,673	0,91	3,82	0,85	0,278	0,01

ZAKLJUČKI

Žgani skeletni ostanki iz gomil nad Razvanjem (*sl. 7*) in v Pivoli (*sl. 8*) so bili skromni, zastopani z bolj ali manj slabo ohranjenimi odlomki žganih kosti, zaradi česar so z analizami pridobljeni podatki omejeni. Analize vseh obravnavanih žganih kosti kažejo na posamične pokope, saj v nobenem primeru ni bilo prepoznati podvojenih skeletnih elementov ali izrazitih razlik v razvitosti različnih delov skeleta, ki bi kazale na več oseb različne starosti. Vendarle gre pri Veliki gomili nad Razvanjem opozoriti, da je bila gomila v preteklosti izropana in so arheološka izkopavanja odkrila dvoje ločenih, vzhodno in zahodno zgostitev žganih ostankov.[16] Izpostaviti velja tudi, da so bili odlomki lobanje, nadlahtnice in podlahtnice zastopani v obeh zgostitvah. Zato pokop dveh oseb ne more biti povsem izključen.

Kosti vseh analiziranih oseb so bile preslabo ohranjene, da bi bilo mogoče ugotoviti spol, izračunati telesno višino ali opaziti patološke spremembe. Starost v času smrti je bilo makroskopsko mogoče le grobo oceniti. Na osnovi debeline (4–6 mm) odlomkov lobanje je soditi, da so bile v vseh obravnavanih grobovih pokopane odrasle osebe. Odprtost lobanjskih šivov pri osebah iz Velike gomile nad Razvanjem in iz gomile 13 iz Pivole (*sl. 8A*) nadalje kaže, da so bile osebe v času smrti mlajše od približno 30 let. Histološka analiza je z analizo mikrostrukture kosti in uporabo regresivne enačbe omogočila oceno starosti osebe iz Velike gomile nad Razvanjem na 30–50 let (*sl. 4*).

V vseh obravnavanih grobovih so prevladovale kosti bele barve (*sl. 7* in *8*), kar kaže na izpostavitev temperaturam nad 650 °C. Glede na izgubo

[15] Snoeck et al. 2014.
[16] Glej tu Strmčnik Gulič, Kajzer, Kramberger.

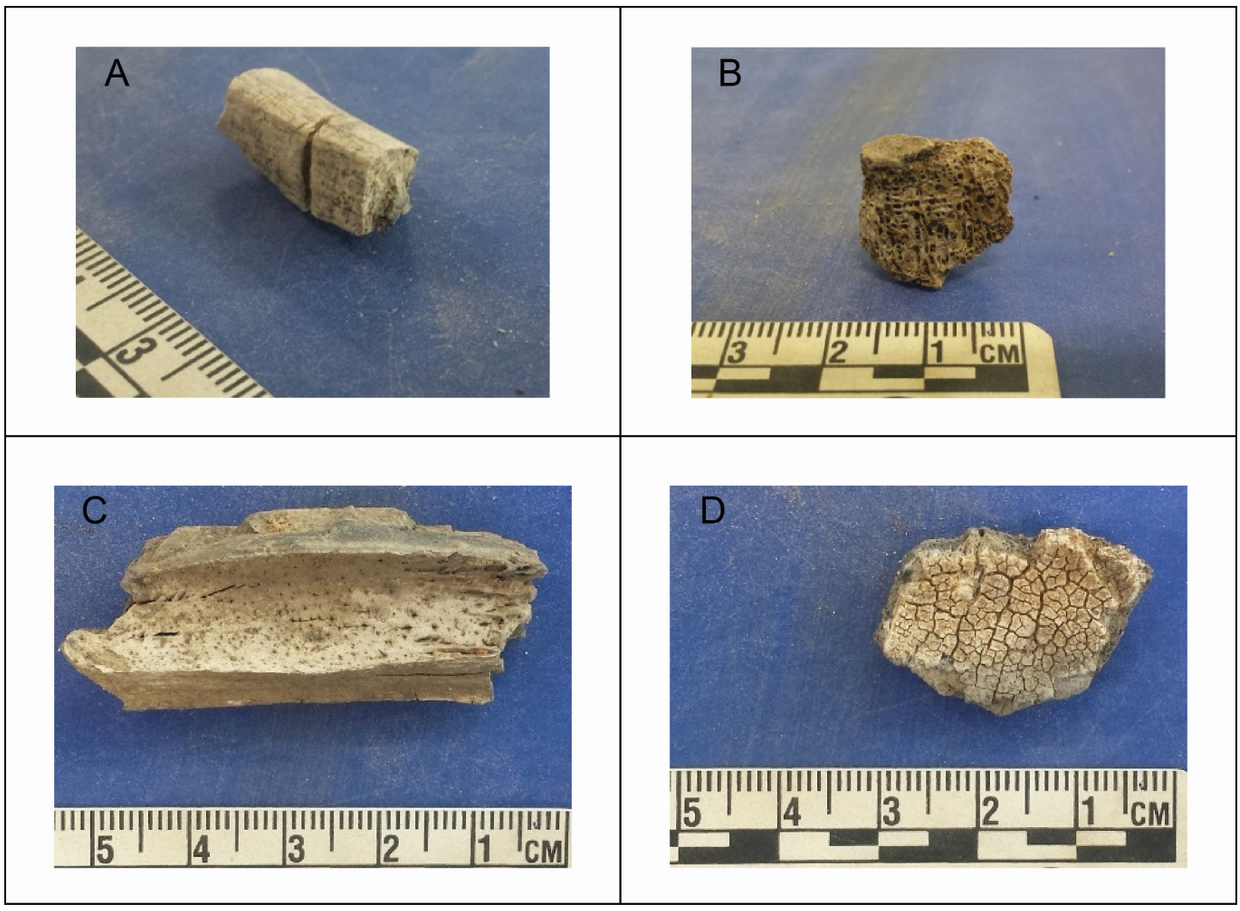
sharper (~ 480–620 cm^{-1}, ~ 900–1150 cm^{-1}) or had almost completely disappeared due to the loss of some components (~870 cm^{-1}, ~1300–1500 cm^{-1}). With the exposure to high temperatures, mineral changes led to the appearance of a new phosphate (PO_4) peak at ~630 cm^{-1} and a cyanamide (CN/P) peak at ~2010 cm^{-1}, the latter being more pronounced in the Pivola sample. The observed changes in the spectra were also confirmed by the calculated ratios, as the amount of the organic matter and carbonates, especially the type B carbonates, had decreased significantly, whereas the splitting factor, representing crystallinity and the order in the mineral lattice has strongly increased (*fig. 6*). Despite noticeable peaks, the cyanamide concentrations were rather low, below 0.25, indicating that they were hardly present.[15]

CONCLUSIONS

The cremated skeletal remains from the three mounds at Razvanje (*fig. 7*) and Pivola (*fig. 8*) were modest, and consisted of poorly preserved fragments of cremated bones with limited data potential. Analyses indicate they were associated with single burials, given that neither duplicate skeletal elements nor pronounced differences in the development of different skeletal elements indicating several individuals of different ages were identified. However, it should be noted that Velika gomila above Razvanje was looted in the past and that archaeological excavations revealed two separate concentrations of cremains in the east and west part of the burial chamber.[16] It should also be stressed that both concentrations contained fragments of the skull, upper arm, and forearm. Therefore, the burial of two individuals cannot be completely excluded.

The bones of all the examined individuals were too poorly preserved to assess the sex, calculate the stature, or observe any pathological changes. The age at death could only be roughly estimated macroscopically. Due to the thickness (4–6 mm) of the cranial fragments, it was concluded that the adults were buried in all the graves examined. The openness of the cranial sutures in the skull from Velika gomila above Razvanje and the other from Mound 13 at Pivola (*fig. 8A*) further indicates that the individuals were less than approximately 30 years old at the time of their death. The histological analysis of the bone microstructure and the regression equation place the age at death of the individual from Velika gomila above Razvanje within the 30–50 years age range (*fig. 4*).

[15] Snoeck *et al.* 2014.
[16] See here Strmčnik Gulič. Kajzer, Kramberger.



Slika 7. Ohranjeni odlomki žganih kosti z značilnostmi iz Velike gomile nad Razvanjem.
A – Odlomek podlahtnice z globoko prečno razpoko.
B – Odlomek telesa vretenca.
C – Odlomek dolge kosti z belo notranjo in sivo prelomno površino.
D – Odlomek lobanje z mrežastimi razpokami na površini.
Figure 7. Preserved cremated bone fragments from Velika gomila above Razvanje.
A – A fragment of ulna with a deep transverse fracture.
B – A fragment of the vertebral body.
C – A fragment of a long bone with white inner surface and grey hues in the cross-section.
D – A fragment of the cranium with fine mesh fractures on the surface.

dvolomnosti pri kosti iz gomile nad Razvanjem gre sklepati, da so bile kosti najverjetneje izpostavljene temperaturam nad 800 °C.[17] Še bolj oprijemljiva izhodišča za oceno temperature, ki so ji bile kosti izpostavljene, nudijo rezultati spektroskopije. Analiza spektrov oz. pojav vrha pri ~630 cm^{-1} priča o izpostaviti kosti nad 700 °C. Glede na razmerja C/C in SF[18] (*sl. 6*) so bile najvišjim temperaturam, verjetno nad 900 °C, izpostavljene kosti iz Velike gomile nad Razvanjem, kosti iz Pivole pa so bile verjetno izpostavljene temperaturam okoli 800 °C. Črni, sivi in modri odtenki prelomnih in notranjih površin vendarle kažejo, da nekateri deli kosti niso bili izpostavljeni tako visokim temperaturam ali dovolj dolgo časa, da bi kosti popolnoma kalcinirale. Odlomki s sivo in modro obarvanimi zunanjimi površinami pričajo o izpostavljenosti temperaturam med 360 °C in 650 °C, sicer redko prisotne črne zunanje površine pa temperaturam pod 360 °C. Izpostavljenost različnim temperaturam je najverjetneje posledica prisotnosti mehkega tkiva, različne anatomske pozicije kosti ali/in dela telesa na grmadi.

Vzorci razpok na odlomkih kosti iz vseh grobov pričajo o hitrih spremembah v vsebnosti kolagena v

In all the graves considered, white bones predominated (*figs. 7* and *8*), indicating that they were exposed to temperatures above 650°C. Given the loss of birefringence in the bones from Velika gomila above Razvanje, it can be concluded that the bones were most likely exposed to temperatures above 800°C.[17] The spectroscopy results made more precise estimates of the firing temperature possible. The spectral analysis and the appearance of a peak at ~630 cm^{-1} testify to the exposure of the bones to temperatures above 700°C. According to the C/C and SF ratios[18] (*fig. 6*), the bones from Velika gomila above Razvanje were exposed to the highest temperature, probably above 900°C. The bones from Pivola were probably exposed to temperatures around 800°C. However, black, grey, and blue shades of the fractures and the inner surfaces indicate that some parts of the bone were not exposed to such high temperatures, or for too short a time, to completely calcify. Fragments with grey and blue outer surfaces indicate that they were exposed to temperatures between 360°C and 650°C, while black outer surfaces rarely show temperatures below 360°C. Exposure to different temperatures is most likely the result of the presence of soft tissue, the different anatomical

17 Mayne Correia 1997, 275–293.
18 Snoeck et al. 2014.

17 Mayne Correia 1997, 275–293.
18 Snoeck *et al.* 2014.

Slika 8. Ohranjeni odlomki žganih kosti iz gomil v Pivoli z značilnostmi: **A** – Odlomek lobanje iz gomile 13 z deloma ohranjenim in odprtim lobanjskim šivom. **B** – Del medenice iz gomile 14. **C** – Odlomki kosti iz gomile 14 z različnimi vzorci razpok na površini.
Figure 8. Preserved bone fragments from Pivola mounds with a number of indicative characteristics. **A** – A fragment of the cranium from the Mound 13 with partially preserved and opened suture. **B** – Part of the os coxae from the Mound 14. **C** – Bone fragments from the Mound 14 with different fracture patterns.

kosteh ter kažejo na prisotnost in krčenje mehkega tkiva med sežigom (U-oblikovane razpoke), izhlapevanje in denaturacijo beljakovin (vzdolžne razpoke), postopno napredovanje ognja navzgor ali navzdol po deblu kosti (prečne razpoke) ter enakomerno izpostavljenost večjih delov kosti visoki temperaturi ali sežig mehkega tkiva (mrežaste razpoke). Ker so temperature presegle 600 °C, je prišlo do vsaj 1–2 % krčenja kosti.

Prisotnost različnih delov skeleta, skupaj z raznoliko obarvanostjo in razpokanostjo kosti, nakazuje na sežig celotnega telesa. Med določljivimi elementi je sicer opaziti prevlado lobanjskih in dolgih kosti, kar je razložljivo z dejstvom, da lobanja in dolge kosti predstavljajo večji delež, 20 % oz. 60 % skeleta. Poleg tega so odlomki lobanje zaradi specifičnih morfoloških lastnosti bolje prepoznavni kot preostali deli skeleta.[19]

Cianamide je zaradi njihove nizke in tako komaj zaznavne vsebnosti težko razložiti. Običajno je njihova prisotnost povezana s sežigom celotnega telesa, torej skupaj z mehkim tkivom ter redukcijskimi pogoji.[20] Glede na to, da ostali rezultati kažejo sežig celotnega telesa, nizka vsebnost cianamidov morda kaže na oksidacijske pogoje, torej visoko razmerje med kisikom in gorivom, kar je značilno za majhne grmade in/ali dobro zračnost.[21]

position of the bones and/or the placement of a body part on the funeral pyre.

Crack patterns on bone fragments from all the graves indicated rapid changes in the collagen content of the bones. They also indicated the presence and contraction of soft tissue during burning (U-shaped cracks); the evaporation and denaturation of proteins (longitudinal cracks); the gradual progression of fire up or down the shaft of the bone (transverse cracks); and the exposure of large parts of the bone to high temperatures or the burning of the soft tissue (reticular cracks). At temperatures above 600°C, there was at least 1–2% bone shrinkage.

The presence of different parts of the skeleton and the different colouring and cracking of the bones indicates cremation of the whole body. Among the identifiable skeletal elements, the skull and long bones predominate, which can be explained by the fact that the skull and long bones make up a major portion of the skeleton: 20% and 60% respectively. In addition, skull fragments are more easily identifiable than the rest of the skeleton due to their specific morphological characteristics.[19]

The cyanamide results are difficult to interpret due to its low and therefore hardly detectable concentrations. Its presence is usually associated with a cremation of the entire body, i.e. together with soft tissue and reducing conditions.[20] Since the other

[19] Trotter, Peterson 1962, 669; Gonçalves 2012; Gonçalves et al. 2015, 82–83.
[20] Snoeck et al. 2014.
[21] Snoeck et al. 2014; Snoeck et al. 2018.

[19] Trotter, Peterson 1962, 669; Gonçalves 2012; Gonçalves *et al.* 2015, 82–83.
[20] Snoeck *et al.* 2014.

Teže ohranjenih človeških kosti iz analiziranih grobov (od 117,3 g do 2019 g) so nizke, močno pod ocenjenim povprečjem človeških žganih ostankov iz arheoloških kontekstov, ki znaša ~1600 g.[22] Razlogi za nizke teže so verjetno posledica različnih okoliščin, od načina sežiga, zbiranja kosti s pogorišča grmade in načina pokopa, do kasnejših poškodb gomil.

results show entire-body cremation, the low cyanamide content may indicate oxidation conditions, i.e. a high oxygen-fuel ratio, characteristic of small pyres and/or good ventilation.[21]

The weight of the preserved human bones from the individual graves (ranging from 117.3 g to 219 g) is low – far below the estimated average of 1600 g for the human cremains from various archaeological contexts.[22] The reasons for the low values are probably linked to a variety of factors ranging from distinct cremation practices to the selective collection of some bones from the pyre for interment at the burial site. In addition, natural post-depositional processes and looting might also have contributed to the small quantity of bones recovered.

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[21] Snoeck *et al*. 2014; Snoeck *et al*. 2018.

[22] McKinley 1993, 285; Gonçalves et al. 2015, 76–77, 80–81.

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