

Bioarchaeological and Palynological Studies of Graves from Samshvilde: Diachronic Case for Preliminary Reconstruction of Environment, Human Diet, Diseases and Remedies

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ARTICLE INFO

Key Words:
Samshvilde
Bioarchaeology
Palynology
Mortality in Archaeology
Trauma analysis

ABSTRACT

This paper presents the results of multidisciplinary research carried out at the Samshvilde Archaeological Complex (Georgia, South Caucasus) between 2016 and 2024 by a team from the University of Georgia, the Georgian National Museum, and Ivane Javakishvili Tbilisi State University. The project aimed to help reconstruction of the aspects of paleoecology, paleodiet, paleopathology, social hierarchy, and medical practices among Late Bronze–Iron Age, Hellenistic, and Medieval communities through the analysis of Samshvilde graves, despite the limited number of burials available. Eight graves spanning different periods were examined using a range of methodological approaches. Palynological analyses revealed widespread helminthic and gastrointestinal infections, which appear to have been treated with traditional remedies, including deer antler and volcanic ash residues identified in the graves. Archaeological evidence indicates a possible spatial shift in mortuary practices: graves from the Late Bronze–Iron Age and Hellenistic periods were concentrated near the Samshvilde citadel, whereas Medieval interments were mainly located in the eastern sector of the city. This transition may reflect demographic, economic fluctuations and broader sociopolitical changes. Bioarchaeological data further suggest that most individuals from the Medieval graves suffered violent deaths, consistent with the historical record of Seljuk, Mongol, and Iranian incursions in the region during the High and Late Middle Ages.

1. Introduction

The Samshvilde archaeological site is located in the southern part of Georgia, in the historical region of Kvemo Kartli. This location held particular strategic and economic significance during the Middle Ages, as it lay along the northern branch of the Silk Road - a major trade and economic route connecting the far East and the West. This positioning further underscores the importance of the region throughout history (Berikashvili, 2016) (Fig. 1).

Due to its strategic geographical position, the Samshvilde area has attracted continuous human settlement since prehistoric times. This is confirmed by numerous burials and early archaeological contexts identified at the site (Bakhtadze, 2007; Berikashvili, 2024). The region's

rich natural resources including proximity to rivers, clay deposits, and obsidian sources—supported human habitation well almost until the 19th century. Archaeological traces of activity are visible throughout the area, highlighting its long-term significance (Chilashvili, 1970; Berikashvili and Pataridze, 2019; La Russa et al., 2019; Randazzo et al., 2020; Berikashvili, 2016: 105–119; 2017).

Recent archaeological research suggests that large-scale settlement at the Samshvilde promontory began in the Early Bronze Age. During this period, megalithic structures made of basalt boulders appeared in the site's eastern and central sectors. These structures, still visible today, are associated with the Kura–Araxes cultural horizon, dating to the 4th–3rd millennia BCE (Sagona, 2018; Mirstskhulava, 1975; Shanshshvili and Narimanishvili, 2022) (Fig. 2).

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<https://doi.org/10.1016/j.qeh.2025.100090>

Received 8 June 2025; Received in revised form 22 October 2025; Accepted 23 October 2025

Available online 26 October 2025

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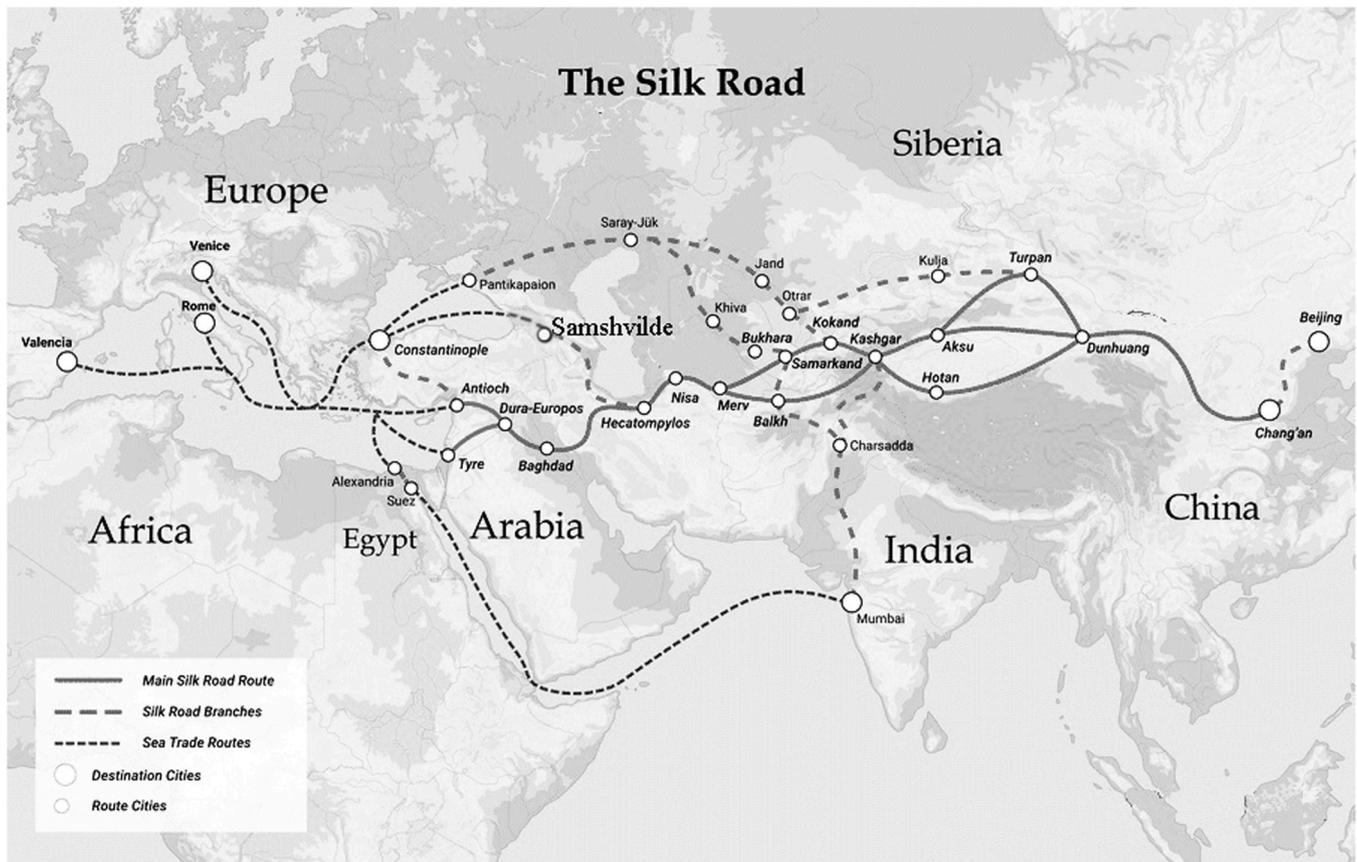


Fig. 1. The “Silk Road” and the location of Samshvilde on its northern branch.

The Middle Bronze Age is less well-represented. Archaeological layers from this period are thin and material remains limited. However, ceramic fragments typical of the Trialeti culture and obsidian arrowheads dating to the mid-2nd millennium BCE have been recovered (Berikashvili and Coupal, 2018; Kvakhadze, 2024). These isolated finds indicate the potential for undisturbed contexts to be uncovered through further excavation (Fig. 2).

The final phase of the Bronze Age in the South Caucasus, represented by the Late Bronze–Iron Age cultural horizon, is well-documented at the Samshvilde promontory (Berikashvili and Coupal, 2019; Berikashvili, 2016; Bakhtadze, 2007). During this period, human activity intensified not only on the promontory itself but also across the adjacent valleys and terraces. Archaeological and multidisciplinary research indicates that Samshvilde’s first major megalithic structure—a cyclopean fortress—was likely constructed during this era. Situated at the narrowest point of the promontory’s central sector, the fortress held significant strategic value.

Although largely destroyed by later human activity, the fortress can be partially reconstructed through surviving megalithic remains found beneath the foundations of medieval walls within the citadel. Stratigraphic and material evidence suggest a construction date at the transition between the 2nd and 1st millennia BCE. These findings provide critical insights into early architectural traditions and the socio-political complexity of Late Bronze–Iron Age societies in the region (Fig. 3).

The archaeological contexts of the subsequent period, specifically the antique era, are represented at Samshvilde by individual ceramic finds (Chilashvili, 1970) and well-defined Hellenistic period burials (Berikashvili, 2024), indicating the presence of a significant settlement and necropolis during this time. Archaeological practice shows that Hellenistic period cemeteries discovered in Georgia are characterized by compactness and the close proximity of burials. Considering this, the discovery of additional burials from the same period within the citadel

area of Samshvilde is entirely plausible.¹

Nevertheless, the most active period in Samshvilde’s history occurred during the Middle Ages, when the site became one of the region’s primary political, economic, and cultural centers. Historical, written sources and archaeological research confirms that the city experienced a significant rise in the 5th century, coinciding with the spread of Sassanian political influence and the strengthening of their power in the South Caucasus (“Kartlis Tskhovreba,” 1955; Sanadze, 2016). It was during this period that the construction of a powerful early medieval fortress was undertaken, occupying the site of the previously destroyed megalithic fortifications.

The 9th–11th centuries in Samshvilde’s history are marked by intense feudal wars and conflicts. This period saw the Tashir-Dzorakert Armenian Kingdom expanding into the historical Georgian region of Kvemo Kartli, temporarily occupying the area. In the second half of the 10th century, members of the Kirakian Armenian dynasty declared Samshvilde the capital of the Tashir-Dzorakert Kingdom and their residence. However, in 1064, King Bagrat IV of Georgia liberated Samshvilde, bringing it back under the protection of the Georgian feudal state (Kutateladze, 2001).

The “Great Turkish Invasion” marked one of the most dramatic periods in the history of Samshvilde and the wider South Caucasus, characterized by a significant decline in the region’s economy and culture. The Seljuk forces, at a low cultural development stage, played a destructive role, not only in the political and economic life, but also in altering the demographic and social structure in Samshvilde and Kvemo Kartli in general. This continued until 1121, when King David IV of Georgia decisively defeated the Seljuk coalition army in the Battle of

¹ Five more graves of the Hellenistic period were discovered in Samshvilde in recent days.



Fig. 2. 1–3 Kura-Araxes pottery fragments from Samshvilde; 4–8 Trialeti Culture pottery fragments from Samshvilde. 9–11 Trialeti Culture obsidian arrowheads from Samshvilde (Photo credit D. Berikashvili and L. Kvakhadze).

Didgori, effectively ending Seljuk control in the region. This victory was pivotal in reshaping political power and influence in the South Caucasus, with Samshvilde falling under Georgian royal control.

From the early 13th century, continuous Mongol invasions destabilized Georgia and the broader South Caucasus, causing the collapse of economic stability and the cessation of the "Silk Road" trade route, vital for East-West connections. South Caucasian cities weakened and suffered economic decline, including Samshvilde, which gradually lost its political and military strength.

Ultimately, historical records confirm that Samshvilde was abandoned by its population in the 18th–19th centuries. This abandonment occurred gradually over several decades, and by the mid-19th century, the historical city was no longer inhabited. The fortress, palaces, "Royal Bathhouse", and other structures were left in ruins.

To enhance understanding of Samshvilde's extensive history, this study examines grave complexes from multiple historical periods, providing critical insights into individual lifeways and experiences within the city. Although the number of graves analyzed within this project is limited, the findings and results offer a valuable foundation for understanding the features of this unique site.²

² Studies have been conducted, among others, on archaeological artefacts (Berikashvili, 2017; 2020), human remains (Berikashvili and Coupal, 2018; 2019), palynological data (Kvavadze, 2023). More about Samshvilde on www.samshvilde.ge

2. Research material and methods

The research material comprises bioarchaeological, archaeological, and palynological finds from the Samshvilde site, analyzed in the laboratories of the University of Georgia and the Georgian National Museum. Given the diversity of the assemblage, multiple methods were employed, including techniques specific to bioarchaeological and palynological analysis, as well as, archaeological material study, and radiocarbon dating. Specifically:

2.1. Bioarchaeological Methods

Sex was assigned for individuals using standard morphological methods (Ferembach et al., 1980; Buikstra and Ubelaker, 1994; Walker, 2008; Acsádi and Nemeskéri, 1970). Age estimation was carried out using - Transition Analysis (TA3)—developed by forensic anthropologist Sara Getz and her team in 2020. (Getz, 2020). In addition, paleopathological conditions were determined through visual examination and description of the abnormal changes observed on the skeletal remains and trauma analysis was conducted considering the chronology, morphology, and fracture characteristics of injuries that were sustained both perimortem and postmortem (Lovell, 1997; Sauer, 1998; Scianò et al., 2020; Kimmerle and Baraybar, 2008). All the studies and research of bioarchaeological materials and human remains were carried out within the framework of the archaeological permit and licenses issued by the National Agency for Cultural Heritage Preservation of Georgia (№6/17/47. 06.27.2018; №6/17/29. 05.22.2019; №6/17/20. 05.20.2020; №6/17/54. 07.19.2021; №6/12/14. 05.4.2023; №6/12/20. 05.28.2024), in accordance with the Georgian Law on Cultural Heritage, and also in full compliance with the ethical norms and guidelines required during the study of human remains, as defined by Georgian legislation.³

2.2. Methodological Aspects of Palynological Analysis of Skeletal Remains

The systematic application of palynological analysis to archaeology began in the second half of the twentieth century, culminating in the establishment of "archaeological palynology" as a distinct discipline by 1983 (Bryant and Holloway, 1983). Initially, the primary focus of palynological studies lay in reconstructing past environments and subsistence strategies, including paleodiet (Bohrer, 1968; Hevly, 1970; Dickson, 1978; Tipping, 1994). Much of the early work concentrated on residues preserved in archaeological vessels, which yielded insights into cultivated plants, food preparation, and storage practices (Rösch, 1999, 2005; Kvavadze, 2006; Kvavadze et al., 2004, 2008; Licheli and Kvavadze, 2011; Moe and Deggl, 2013).

The extension of palynological methods to burials marked a decisive shift. A landmark case was the analysis of Neanderthal remains from Shanidar Cave IV in Iraq, where pollen evidence indicated not only the season of interment but also a funerary tradition involving the placement of flowers on the grave (Leroi-Gourhan, 1975). This discovery fundamentally altered interpretations of Neanderthal cognition and symbolic behavior. Another milestone was the study of Upper Paleolithic layers at Dzudzuana Cave in Georgia, where flax fibres dated to ~35,000 years ago revealed early human abilities to spin threads for ropes, bags, and possibly clothing (Kvavadze et al., 2009). These examples demonstrated that palynology could move far beyond paleo-environmental reconstruction, providing direct evidence of cultural practices, technology, and symbolic behavior.

In recent decades, the scope of burial studies has expanded considerably, particularly with the analysis of organic residues adhering to

³ <https://www.scribd.com/document/814345442/Law-of-Georgia-On-Cultural-Heritage>



Fig. 3. Aerial view of Samshvilde Medieval Citadel and remains of Bronze Age Megalithic structures beneath it (Photo credit D. Beirkashvili).

human skeletal remains. A pivotal development was the methodological framework established during investigations at the Saphar-Kharaba cemetery (Kvavadze and Narimanishvili, 2006, 2010; Kvavadze et al., 2010). Exceptional preservation of skeletons at this site allowed detailed anthropological analyses of age and sex, while systematic sampling of organic residues—beneath the skull, hands, thighs, abdominal region, knees, and feet—yielded rich and taxonomically diverse palynological assemblages. The exceptional preservation of palynomorphs confirmed that these residues offered valuable evidence about burial practices and environments. Subsequent applications of the Saphar-Kharaba sampling protocol across multiple cemeteries in Georgia validated the method and confirmed its reproducibility (Bitadze et al., 2011; Sikharulidze et al., 2012; Makharadze et al., 2013; Chichinadze et al., 2012, 2019; Lomitashvili et al., 2020; Bakhtadze et al., 2023; Kvavadze, 2023).

A further methodological advance has been the inclusion of non-pollen palynomorphs—wood parenchyma, fungal spores, algae, insect fragments, and textile fibres—alongside pollen in burial analyses (Van Geel, 1998; Van Geel et al., 2003). These complementary indicators enhance reconstructions of past lifeways. Textile fibres, for example, recovered from femora often represent clothing remains; their morphology reveals weaving techniques, while in many cases their original coloration is preserved (Kvavadze and Narimanishvili, 2006, 2010; Kvavadze and Gagoshidze, 2008; Chichinadze and Kvavadze, 2025; Gagoshidze and Kvavadze, 2014; Bedianashvili et al., 2022; Kvavadze et al., 2008, 2019, 2020). Such finds provide rare, direct evidence for dress and material culture.

Analyses have consistently shown that residues beneath the skull yield particularly rich and informative palynological spectra. Bronze Age, Classical, and Medieval burials from across Georgia (Kvavadze et al., 2010, 2020; Bitadze et al., 2011; Lomitashvili et al., 2020; Kvavadze, 2023) demonstrate the value of these samples. A striking example comes from the Zhinvali cemetery, where the hair of a 12–15-year-old girl (Burial No. 375, dated to the 6th–7th centuries AD) preserved an exceptionally diverse pollen assemblage (Chikhladze and Kvavadze, 2011). To explore why skull and hair residues are so taxonomically rich, an experimental study was undertaken in Kartli. A participant refrained from washing her hair for ten days; subsequent palynological analysis of rinse water revealed pollen from local wild flora, cultivated plants, and kitchen garden crops, alongside insect remains, ticks, and textile fibres from household environments (Bitadze et al., 2011; Kvavadze et al., 2020). The study confirmed that human hair, when coated with natural oils, acts as a trap for micro-remains from the surrounding environment,

daily activities, and domestic settings. Although hair rarely survives archaeologically, resistant palynomorphs it once carried are often preserved beneath the skull, enabling reconstructions of habitat, economy, household tasks, and even the season of burial.

Other body regions yield equally valuable information. Samples from the abdominal cavity and inner pelvic surfaces preserve micro-remains of digested food and medicinal plants consumed shortly before death, while also frequently containing parasitic worm eggs (Kvavadze and Shatberashvili, 2010; Kvavadze, 2016; Kvavadze et al., 2010). Residues beneath the soles of the feet capture traces of footwear, socks, and soil particles rich in palynomorphs, reflecting both clothing practices and the landscapes traversed by the deceased in their final days (Kvavadze, 2023). Collectively, these findings illustrate that palynological sampling of different anatomical regions provides complementary datasets, enabling a multifaceted reconstruction of lifeways and mortuary practices.⁴

2.3. Material and laboratory processing of organic remains of skeleton bone material and other inventories

The available archaeological and palynological data provided the methodological foundation for the investigation of Graves at Samshvilde, initiated in 2012 by the University of Georgia and still ongoing. A total of twenty-nine samples were collected from seven graves of different chronological phases. Of these, twenty-three samples proved suitable for analysis, yielding sufficient quantities of palynomorphs for statistical assessment. Altogether, the material contained pollen and spores representing 46 plant taxa, along with 44 distinct types of non-pollen palynomorphs (Table 2).

Sample preparation was carried out in the palynological laboratory of the Georgian National Museum, following established procedures (Erdtman, 1969; Moore et al., 1991). Approximately 40–50 g of sediment from each sample was first boiled in a 10 % potassium hydroxide (KOH) solution for 15–20 min to disaggregate organic matter. The residue was subsequently washed through a fine sieve and allowed to settle for 24 h. In the next stage, the sediment underwent centrifugation in a

⁴ Along with Bioarchaeological and Palynological methods, MOLAs archaeological field methods were applied for the grave excavations and radiocarbon date determination was conducted at the AMS laboratory of the Arizona University (USA).

Table 1

Table of bioarcheological and archaeological data observation (according to D. Berikashvili, Is. Coupal, N. Tavartkiladze).

Section	Citadel	At the Citadel	Sioni area	Sioni area	Sioni area	Sioni area	Sioni area	Sioni area
Grave	1	2	3	4	5	6	7	8
Discovery date	2018	2023	2019	2017	2016	2023	2023	2023
Location	Trench 68	Trench 45	Trench O8	Trench O8	Trench O17	Trench O18	Trench O18	The bulk O17-O18
Period	LB-IR. Age	Hellenistic	Middle Age	Middle Age	Middle Age	Middle Age	Middle Age	Middle Age
Date C14	BC 808–723	BC 50–10	1230 (by coins)	890–979 AD	1420-1450 AD	1171–1223 AD	1171-1222 AD	1165–1216 AD
Burial type	Single primary	Single primary	Single primary	Single primary	Pit burial	Pit burial	Pit burial	Pit burial
Burial structure	Pit/refuse pit	Pit	Pit	Pit	Pit	Cut in the bedrock	Cut in the bedrock	Cut in the bedrock
Num.of Individuals	1	1	1	1	1	2	1	1
Sex	Male	Male	Female	Female	-	-	-	Male
Estimated Stature	163–171	-	143–159	143–150	-	100–130	90–110	163–169
Age range	35–55	35–45	35–55	35.5–55.4	16–25	7–11	8.5–13.5	18–25
Degree of articulation	Semi-articulated	Semi-articulated	Disarticulated	Articulated	Very poor	Semi-articulated	Semi-articulated	Articulated
Direction of the head	W	N/W	S	W	W	W	W	W
Position of the body	Crouched	Semi-flexed	-	Extended supine	Extended supine	Extended supine	Extended supine	Extended supine
Grave goods	Antler, Jug with zoomorphic handle	Jug, pot, coin, beads, 2 bracelets, arm bracelet	Jug, textile, 10 silver coins, iron ring, pot	Textile	Ring, Glass button	„Empty” button; Bead.	None	Iron nail; Bead.
Trauma	Peri-mortem sharp and blunt force trauma on the skull	None	Peri-mortem blunt force trauma on the temple bone	None	Peri-mortem sharp force trauma	Peri-mortem blunt force trauma on the skull	Peri-mortem blunt force trauma on the skull	Peri-mortem blunt force trauma on the skull
Pathology	Osteoarthritis, Sacralization	Skin diseases (?)	Hip Dysplasia	None	None	None	None	None

heavy liquid (sodium polytungstate) to separate mineral from organic fractions. The denser mineral particles accumulated at the bottom, whereas the lighter organic material floated to the surface. Finally, the organic fraction was acetylated, a process that darkened the palynomorphs and enhanced the visibility of their diagnostic morphological traits.

Microscopic identification and counting of palynomorphs were undertaken with an Olympus BX45 light microscope at magnifications of 200–400 ×. Statistical analysis and graphical plotting of the data were performed using Tilia software (Grimm, 2021). This methodological framework ensured both the reliability of identifications and the comparability of results with previously published palynological studies.

3. Bioarchaeological and Archaeological contexts and interpretation of the graves

As noted above, the Samshvilde site is situated on a basalt promontory and encompasses a long sequence of historical periods (Fig. 4). Within this broader context, a central focus of the present study has been the investigation of graves, selected to shed light on social status, economic conditions, and mortuary practices, while also generating bioarchaeological and palynological data relevant to environmental reconstruction. Eight graves, located on the central and eastern sections of the promontory, were subjected to detailed analysis (Fig. 5). The combined material and skeletal evidence has proven highly informative, offering insights not only into the life histories and causes of death of the interred individuals, but also into the ways in which Samshvilde fits within wider historical and environmental trajectories.

The graves derive from different contexts: Grave 1 was uncovered in trench 68 of the citadel; Grave 2 near its eastern wall in trench 45; while the remaining interments (Graves 3–8) were located in the Sioni area to

the north and northeast of the cathedral, distributed across trenches O8, O17, and O18 (Fig. 5). All contained archaeological and bioarchaeological material, and soil samples were collected for palynological analysis and ecosystem reconstruction.⁵

Grave 1. A vessel fragment with a zoomorphic handle, depicting a long-necked, horned animal, was found at the feet of the deceased. Its ornamentation, with relief and zigzag incision, is characteristic of the Late Bronze–Iron Age of eastern Georgia (12th–7th c. BCE) (Pitskhelauri, 1973). A damaged deer antler, common in Georgian burials and potentially linked to ritual or medical practices (Pitskhelauri, 1973; Gobejishvili et al., 2023), was recovered near the chest. Skeletal analysis revealed degenerative conditions (osteoarthritis, sacralization), severe dental wear, and a tibial growth, suggesting chronic discomfort, heavy activity, and an abrasive diet. Two cranial injuries - one sharp-force (likely axe) and one blunt-force (likely mace) - were lethal, causing fatal brain trauma (Fig. 6. 3–4).

Grave 2. This pit grave contained two clay vessels (a jug and a small pot) placed behind the head, along with beads, two bronze temple rings, two iron bracelets, and a silver drachma of Parthian king Phraates IV (37–2 BCE) deposited in the mouth as a “Charon’s obol” (Berikashvili, 2024). Radiocarbon dating and grave goods confirm a late Hellenistic context. No trauma was observed, but volcanic ash in the soil suggests

⁵ A number of the burials examined in this study—specifically Graves 1, 2, and 3—have previously been published in various academic journals (Berikashvili and Coupal, 2018, 2019; Berikashvili, 2020, 2024). Nevertheless, newly acquired data, revised interpretations of the material, and the results of high-precision radiocarbon dating necessitated adjustments to both the numbering and chronological attribution of these graves. The present article incorporates these revisions and provides an updated framework for their contextualization.

Table 2
Quantitative contents of pollen and non-pollen palynomorphs from Samshvilde graves (according to E. Kvavadze).

Samshvilde Site	Grave 1		Grave 2		Grave 3			Grave 4			Grave 6,7,8					
Taxons, NPP	skull	abdomen	under skull	skull area	abdomen	knees	skull	abdomen	pelvis	skull	abdomen	pelvis	skull	abdomen	pelvis	feet
Pinus	3	3	7	2	2	2	1		2	2	1	2	5	4	3	3
Juniperus																1
Alnus							1			1	1	1				2
Ulmus						1							1	1		
Juglans regia							1	1	1							
Carpinus betulus	2	1	1	1			1			1			2			
Quercus							1									
Tilia					1		1						1	1	1	1
Zelkova carpinifolia	1	1		1		1										
Corylus			1				1	1			1	2		1	2	
Sorbus		1			1									1	1	
Ilex														1	1	1
Vitis vinifera								1								
Vitis silvestris							1									
Cerealia		1	3	1		1								2	3	4
Poaceae		2	1		1								3	4	4	5
Triticum		1	1		7		2	4	1		1		8	2	2	2
Polygonum	1	1						1	1				3	2	1	1
Polygonum aviculare													1			1
Carduus					1		5	1			1	1	3	2		1
Serratula							2						1			
Xanthium		1						2						2		2
Centaurea					1	5		2	1				2	3	1	2
Achillea					2			2						2		4
Crepis aurea					4									2		
Aster	2		1		1	1	1	1	1	2	1	1		2	6	5
Artemisia													4	3	1	1
Plantago major/P. media								1	3					1	1	1
Plantago cf. P. lanceolata													2		1	5
Cichorioideae	3		8	3	7	3	11	3	5	3	2	10	31	12	7	8
Chenopodiaceae			2					2	1		2		5	2		
Convolvulus	1			1	1											
Apiaceae								2					4	6	2	1
Apium					2			2					3	4		
Lamiaceae								1					2	5	2	1
Rumex								3				1				
Urtica								1		2		12	1			
Malva									1				1			
Ranunculus													2			
Caryophyllaceae													2			
Liliaceae													1			
Polypodiaceae	1	1	1	2	1	6	3	5	2	2		2	2	4	2	4
Pteridium aquilinum		3					1	2		1	2		1			
Sphagnum																1
Undiff. Ascospores			23	15	25	37	20	17	20	61	8	21	56	16	46	16
Sordaria							6			1			1	1	5	17
Glomus	3	5	4	4	2	6	15	11	18	21	20	38	32	10	22	47
Mycoraceae				1		1					2		1			1
Altelnaria													1			2
Thecaphora			2					2	1							1
Neurospora			2													
Chaetomium			1							1			4			3
Tracheal cells of und. wood	6	20	104	101	98	109	89	99	82	82	93	95	256	171	169	177

(continued on next page)

Table 2 (continued)

Samshvilde Site	Grave 1		Grave 2		Grave 3			Grave 4			Grave 6,7,8					
Tracheall cells of Pinus	2	2	6	9	7	15	10	6	8	3	3		23	2	17	4
Tracheal cells of Ulmus		1	2		4	5	7			2	4				2	
Phytoliths of Pooideae	7	18		4	27		16	12	27	4	4	5	90	40	93	47
Phytoliths of Cerealia	3	5					9	7			1		2	6	14	4
Undif. starch grains	28	30	7	32	22	28		10	22	2	5	6	14	12	42	29
Starch of Cerealia	15	22	7	2	3	14	14	12	12		2	2	2	13	20	23
Starch of Triticum	2	4											4	2		
Fibre of flax	2	3		2		4	5	7	6	2	3	4	67	25	28	9
Pink fibre of flax	4	1														
Brown fibre of flax													1			
Blue fibre of flax		1											10	4	2	1
Gray fibre of flax																1
Fibre of cotton	1	2						1								
Black fibre of cotton							2						2	5	1	
Red fibre of cotton							1						1			1
Blue fiber of cotton					1						1		2		1	1
Fibre of hemp				1				2					4	4		
Fibre of wool													1		2	
Dinoflagellata		1	2				2	4	5	2	3	3	2	2		5
Spirogyra	1	2	1		1	2	1				2		2	4	3	2
Pseudoschizaea					2	1	1	1	1	1	1			1	1	3
Undiff. algae			4	4	1	2	7	15	10	6	10			4		1
Zooepidermis				2	3	7	10	18	17	12	15	13	3	1	9	2
Undiff. zoomaterial							25	30	15	15	19	5	3		23	
Plant epidermis		3	4		5	7	20	21	16	13	12	10	28	34	29	11
Hair of insecta							4	9							4	4
Claw of acari				1	2				5				2			3
Hair of acari			3					14					2			4
Hair of bee													2			1
Feather of bird				1			2									
Egg of Enterobius			1			1		1	1			1		1		1
Egg of Fasciola hepatica										1		1				
Egg of Cappilaria																1
Undiff. eggs of helminths					1								1		1	1
Bone salt crystals				8	20	5				12		4				
Tephra				5	10											
Total Pollen and NPP Sum	74	120	173	192	224	254	280	285	266	240	209	208	619	358	534	423



Fig. 4. Aerial view of Samshilde Citadel and Sioni Area on Samshilde Promontory (Photo credit D. Beirkashvili).

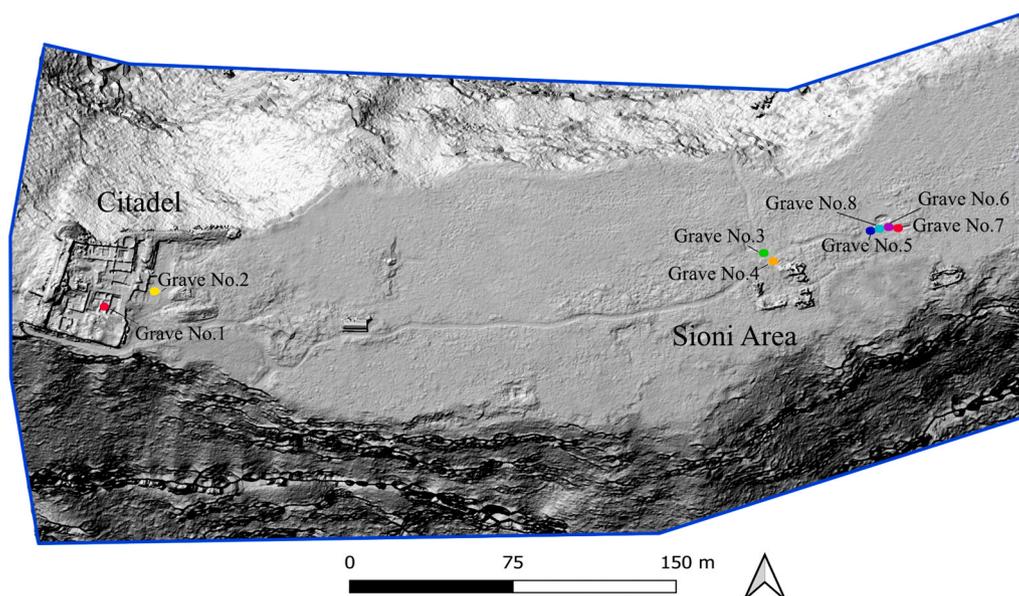


Fig. 5. Distribution of the graves studied in the citadel and on Sioni area of Samshilde (© Lidar survey base map by S. Field and D. Berikashvili. 2025).

therapeutic use, possibly for skin conditions (Fig. 7; Fig. 18).

Grave 3. Although disturbed by later medieval activity, this burial contained a jug, a two-handled pot, an iron ring, and ten silver coins dating to Queen Rusudan's reign (1230 CE), likely deposited in a purse (Berikashvili, 2020). The individual, an elderly female (~55 years), suffered congenital hip dysplasia, a condition causing severe lifelong impairment. Her survival indicates long-term social care, providing evidence of medieval communal support and empathy (Fig. 8).

Grave 4. No grave goods were recovered from this burial. However, soil analysis revealed the individual was clothed in red-dyed cotton. Bioarchaeological evidence indicates a physically active lifestyle, as shown by strong muscle attachment sites on the femur and humerus. Dental analysis revealed calculus on multiple teeth, suggesting a diet rich in carbohydrates or proteins that promotes plaque formation (Fig. 9).

Grave 5. The remains, belonging to an adolescent, were partially

preserved. Later disturbance accounts for missing skeletal elements. A glass button and bronze ring were recovered, suggesting richer original furnishings. Bioarchaeology indicates high activity levels, dental calculus, and a sharp-force vertebral injury, most likely fatal. The context may relate to the 1440 CE attack on Samshilde by Jahan Shah (Fig. 10).

Grave 6. This double burial is here represented by the lower individual, a child aged 7–11 years. Grave goods were limited to a bead and a metal button. A sharp cranial perforation with radiating fractures indicates perimortem trauma, consistent with a mace strike. The violent death suggests the child was a civilian victim of enemy incursions. (Fig. 11).

Grave 7. Similar evidence was identified in Grave 7, where an adolescent also suffered fatal cranial trauma. Bioarchaeological analysis revealed heavy physical stress prior to death. The context, again, is consistent with incursions into Samshilde. No artifacts were associated with the burial (Fig. 12).

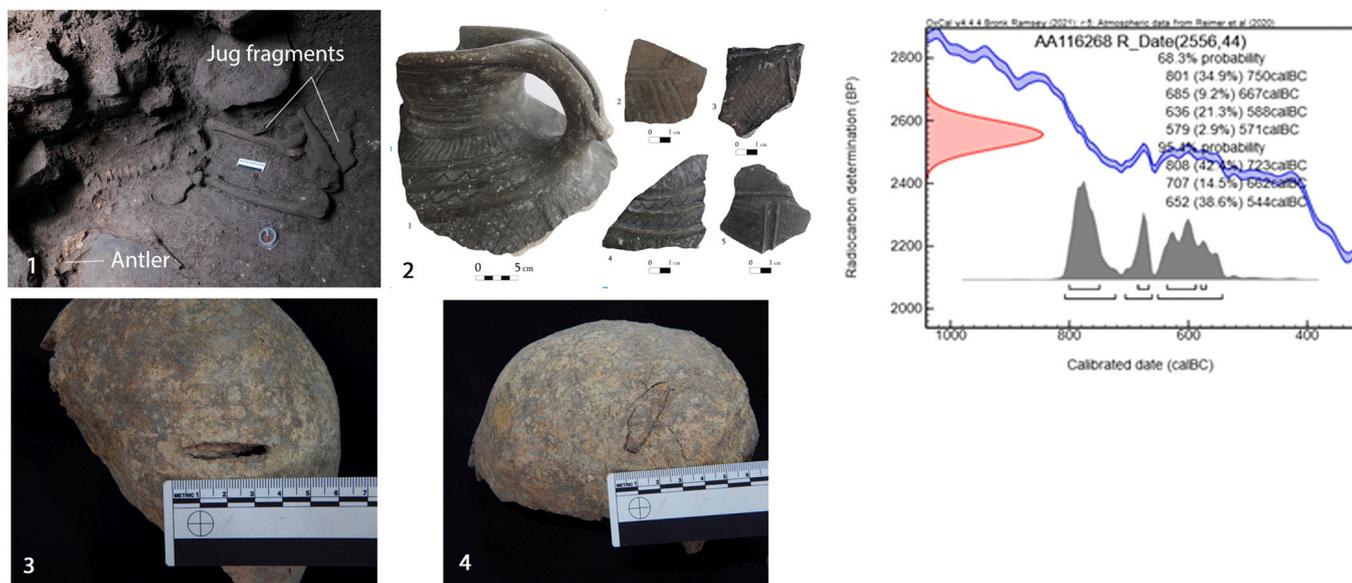


Fig. 6. Grave 1: 1. Human remains inside the grave in the semi-flexed position; 2. The fragments of a jug with zoomorphic handle; 3-4. The death cause traumas with sharp and blunt objects on the skull (Photo credit D.Berikashvili).



Fig. 7. Grave 2: 1. Human remains in the semi-flexed position; 2. Grave goods: 1. Jug, 2. Beads, 3-4 forehead rings, 5. Pot, 6. Arm bracelets, 7. Silver Drahma of Phraates IV of Parthia (Photo credit D. Berikashvili).



Fig. 8. Grave 3: 1. Disarticulated human remains in the grave; 2. Coins in situ in the grave; 3. Grave goods: 1. Jug; 2. Textile fragment attached on the coin; 3-5. Silver coins; 4. Iron ring; 6. Pot. (Photo credit D. Berikashvili).

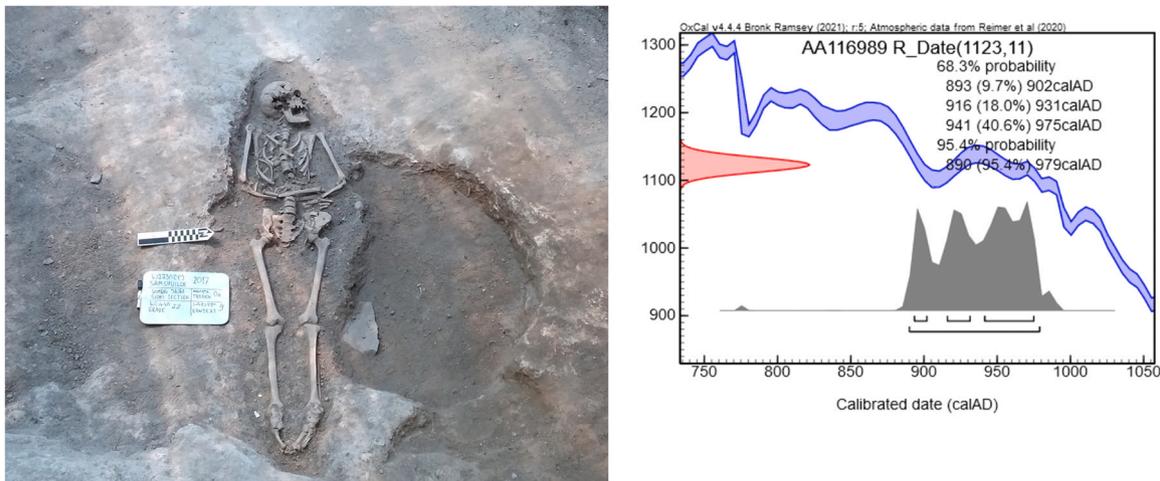


Fig. 9. Grave 4 was slightly cut into the bedrock. On the right side of it another pit (Photo credit D. Beirakashvili).

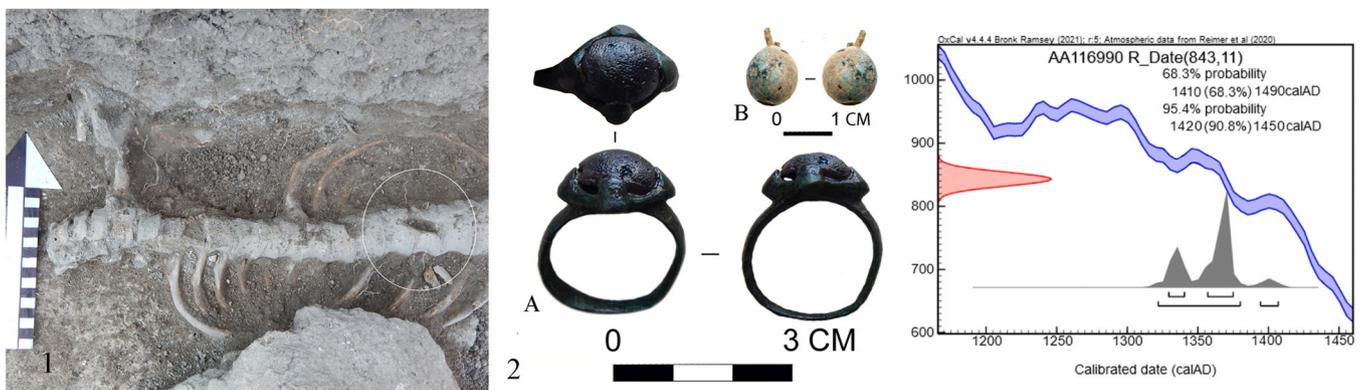


Fig. 10. Grave 4: 1. Sharp trauma in the lower part of the vertebrae; 2. Grave goods: A - the ring; B - Glass button. (Photo credit L. Kvakhadze & D. Berikashvili).

Grave 8. An individual aged 18–25 years exhibited a depressed cranial fracture at the frontal–parietal junction, likely caused by a mace. Grave goods included a red bead and an iron nail in the oral cavity. While object placement in the mouth is a known funerary custom, the nail is considered intrusive, likely introduced post-depositionally through later disturbance (Fig. 13).⁶

4. Results of the palynological analysis and preliminary interpretation

In addition to the bioarchaeological and archaeological approaches, the palynological analysis of the graves offers a valuable dataset for reconstructing aspects of health, environment, and ritual practices spanning from the Late Bronze–Iron Age to the Late Middle Ages. The following sections present a synthesis of the principal palynological findings from all investigated graves emphasizing the identified spectra and their relationship to associated material culture, as well as their integration with bioarchaeological interpretations.

Grave 1. The sample taken from beneath the skull contained only a small number of arboreal pollen grains (Table 2), yielding limited paleoenvironmental information. However, the abdominal sample proved particularly revealing. It contained pollen of several medicinal taxa, including chicory (*Cichorium*), yarrow (*Achillea*), and rowan (*Sorbus*). These plants are frequently associated with the treatment of

gastrointestinal disorders, suggesting that the deceased may have suffered from chronic illness.

The association of deer antlers placed in the abdominal cavity is especially noteworthy. Archaeologists and ethnologists have debated whether such remains had primarily ritual or medicinal functions. Modern ethnopharmacological research increasingly supports the latter interpretation, as recent clinical studies demonstrate that antler-derived compounds have therapeutic properties, including for digestive ailments (Orasoy et al., 2024; Nazarbek et al., 2024).

In addition, textile remains were preserved in the chest cavity. Microscopic analysis revealed both linen and cotton fibres, dyed in blue and red (Fig. 14). The presence of coloured fabrics in this early burial provides valuable evidence of textile use, possibly indicating elevated social status.

Grave 2. Palynological analysis of material beneath the skull yielded a rich pollen spectrum dominated by forest taxa (Figs. 15–16). Most striking was the identification of *Zelkova carpinifolia*, a relict tree species no longer extant in Kartli due to its requirement for warm, humid conditions (Kvavadze and Connor, 2005). Its presence indicates that local forests were more diverse and climatically suitable during this period.

The abdominal sample contained pollen of several plants with medicinal significance, alongside only two edible taxa. These included centaury (*Centaurea*), aster (*Aster*), rough cocklebur (*Xanthium*), plumeless thistle (*Carduus*), bindweed (*Convolvulus*), chicory, golden hawk's-beard (*Crepis aurea*), and yarrow. Such an assemblage strongly suggests medicinal use, possibly for gastrointestinal disorders. This diagnosis is reinforced by the recovery of a parasitic worm egg (pinworm, *Enterobius*), confirming helminthiasis (Fig. 17).

⁶ For more detailed description of the grave goods and bioarchaeological dataset see Table 1.

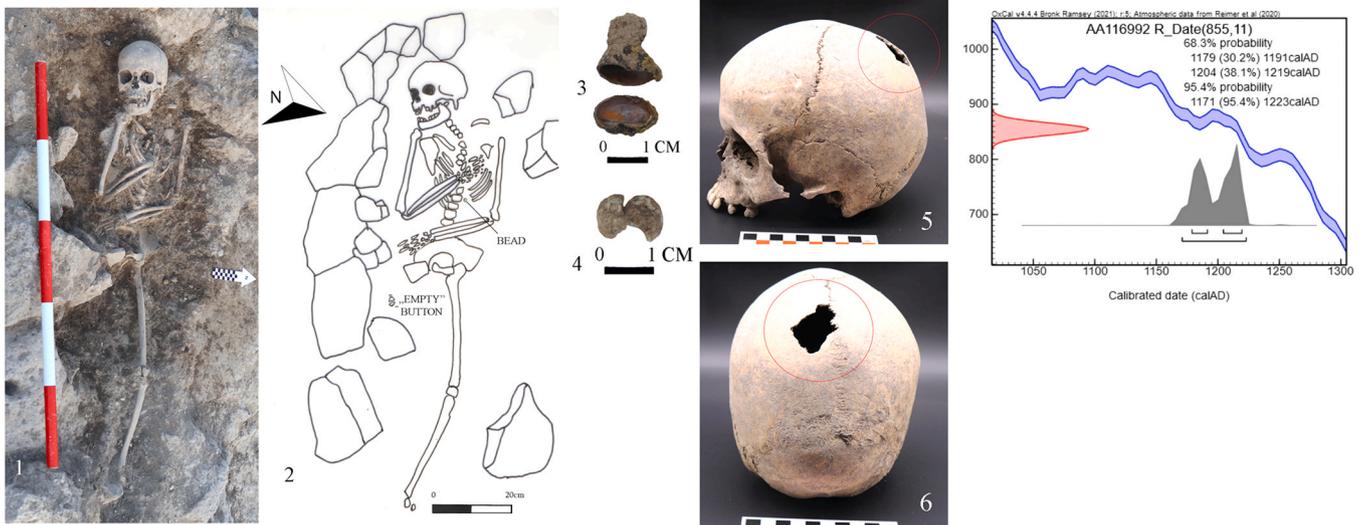


Fig. 11. Grave 6: 1–2. Lower individual after removing upper one (Photo and drawing by D. Berikashvili); 3–4 “Empty” button and bead (Photos by Sh. Tvaladze); 5–6. Life period trauma on the skull (Photo credit N. Tavartkiladze).

Additional unusual findings include traces of volcanic ash preserved on the facial and knee bones (Fig. 18). Volcanic ash, when mixed with water to form bentonite clay, has long been used for therapeutic purposes, particularly skin treatments (cf. <https://sciencestruck.com/uses-of-volcanic-ash>). Comparative data from a Classical-period cemetery at Kanchaani confirm this practice: a medicine bottle containing volcanic ash alongside plant and insect remedies for digestive ailments was discovered, deliberately placed on the abdomen of the deceased (Kvavadze et al., 2023). The parallels with the deer antlers in Grave 1 highlight a recurring tradition of placing medicinal items in abdominal regions.

The palynological data further indicate that this individual died suddenly. Pollen from both yard plants and forest taxa beneath the skull suggests the deceased had been in both settings shortly before death. The absence of summer-specific taxa supports the conclusion that he likely died in the colder season.

Grave 3. The Grave contained a woman aged 35–55 years. Palynological evidence demonstrates that she spent considerable time

outdoors, particularly in household yards and cultivated areas. Disintegrated hair beneath the skull retained abundant pollen of walnut (*Juglans*) and hazel (*Corylus*) orchards, as well as common yard weeds. Spores of dung fungi were also present, reflecting a domestic environment with livestock. The spectrum was further enriched by remains of insects, ticks, and other invertebrates (Fig. 19), indicating death during the warm season, most likely summer.

Abdominal and pelvic samples contained wheat pollen, starch grains, and phytoliths (Fig. 19), suggesting recent consumption of cereal-based food. These findings provide evidence for both subsistence practices and seasonality of death.

Grave 4. The deceased, a man aged 35–53 years, exhibited skeletal features suggesting overall good health and an active lifestyle. Palynological analysis corroborates this, with a relatively modest but balanced spectrum beneath the skull, including pine (*Pinus*), alder (*Alnus*), horn-beam (*Carpinus*), nettle (*Urtica*), bracken fern (*Pteridium aquilinum*), aster, and *Cichorioideae*. Non-pollen palynomorphs included freshwater algae (*Dinoflagellata*, *Pseudoschizaeae*) and wood cells. Abdominal and

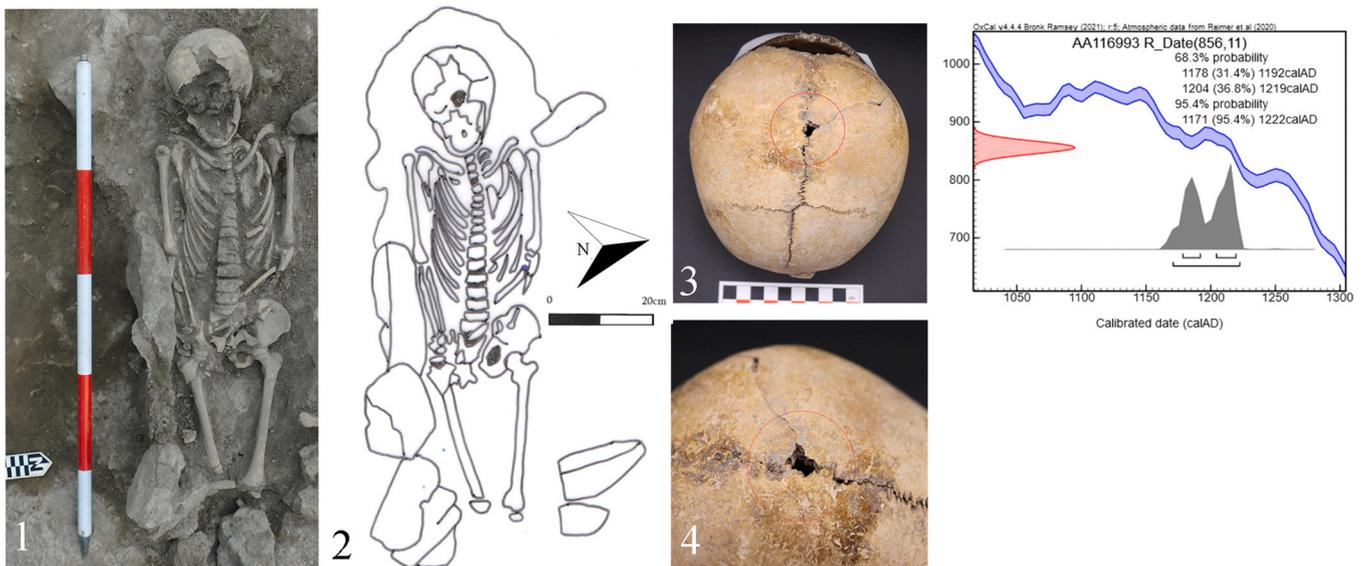


Fig. 12. Grave 7: 1–2 Skeletal remains after excavations (Photo and drawing by D. Berikashvili); 3–4 peri-mortem blunt force trauma on the skull (Photo credit N. Tavartkiladze).

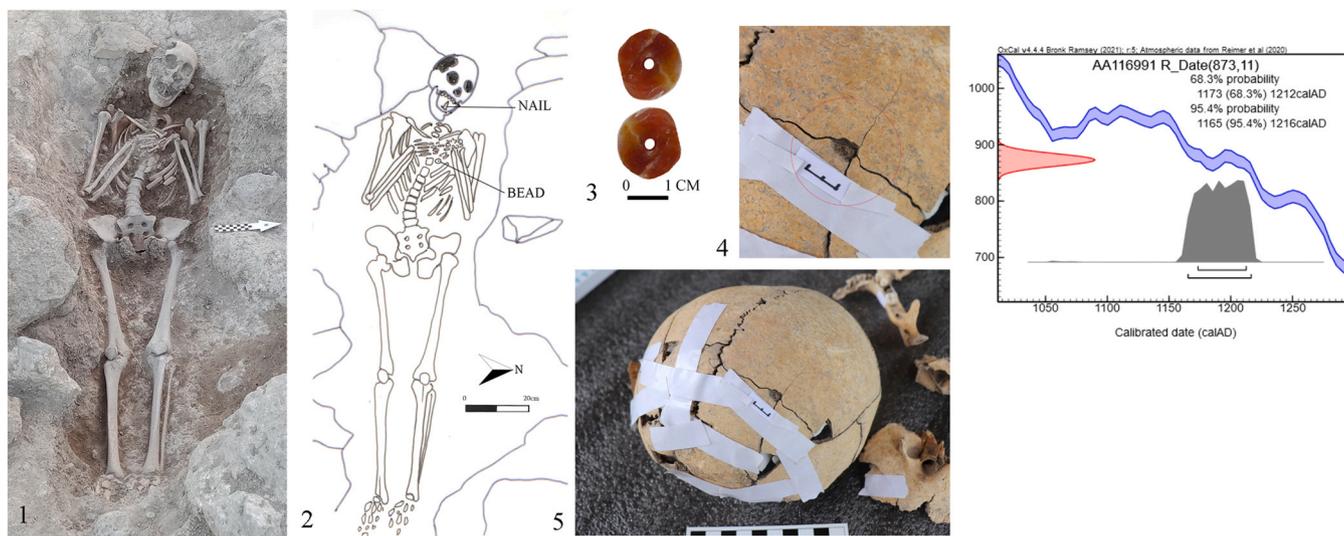


Fig. 13. Grave 8: 1–2 Skeletal remains after excavations (Photo and drawing by D. Berikashvili); 3 Bead (Photo by Sh. Tvaladze); 4–5 Life period trauma on the skull (Photo credit N. Tavartkiladze).

pelvic samples were dominated by edible taxa—hazelnut, wheat, and goosefoot (*Chenopodium*)—alongside medicinal plants such as alder, plantain (*Plantago*), and plumeless thistle. Notably, an egg of the parasitic liver fluke (*Fasciola hepatica*) was identified, explaining the medicinal plant use. Textile fibres were also abundant, including red-dyed cotton (Fig. 20).⁷

Grave 6. The palynological spectrum beneath the skull included 13 taxa: pine, linden (*Tilia*), wheat, buttercup (*Ranunculus*), plantain, centaury, wormwood (*Artemisia*), and members of Caryophyllaceae and Liliaceae. The presence of forest ferns suggests that the child had visited woodland in the days preceding death. Textile remains were abundant, including linen fibres dyed brown (Figs. 20,1). Abdominal and thigh samples were dominated by melliferous and medicinal plants such as linden, wormwood, celery, centaury, and chicory. Starch and wheat phytoliths indicate cereal consumption, while textile fibres included linen, cotton, and wool. The foot sample, however, was markedly different, containing dung fungi (*Sordaria*), pinworm eggs, and diverse fungal spores.

Grave 7. The deceased was a child aged 7–11 years, whose cause of death was likely a cranial wound. Palynological evidence confirms sudden death. Pollen spectra beneath the skull indicated both forest vegetation and meadow/courtyard taxa, suggesting mobility between environments shortly before death. Abdominal and pelvic samples showed recent consumption of nuts, wheat porridge, and honey, supported by the presence of bee setae and melliferous pollen.

Pinworm eggs were again detected, confirming helminthiasis. Textile evidence included numerous linen fibres, some dyed dark or light blue (Fig. 20). The colour is significant: in the medieval period, blue textiles were typically associated with elite status. Comparative burials from the Bagrati Cathedral (Bitadze et al., 2011) and the tomb of King Levan Bagrationi (Bakhtadze et al., 2023) provide strong parallels.

Grave 8. This burial contained a young man aged 18–25 years, who suffered a major cranial injury. Palynological evidence suggests sudden death, with food remains (wheat starch, flaxseed oil residues) preserved in the abdominal and pelvic regions. Under the skull, nettle pollen was found, suggesting the use of poultices or decoctions for wound treatment, consistent with nettle's known antiseptic and analgesic properties (Gilani and Ghayur, 2004; Dyubeni and Buwa, 2012). Non-pollen

palynomorphs included freshwater algae (*Pseudoschizaeae*), indicative of a warm climatic phase (Scott, 1992). Given the contemporaneity of Graves 6, 7, and 8, their spectra display many shared elements, and are therefore presented in combined form in Table 2.

5. Discussion

The multidisciplinary study of human graves from Samshvilde provides valuable insights into both the environment and lifeways of past populations. Bioarchaeological data, particularly age-at-death assessments, contribute to estimates of life expectancy and demographic patterns, while palynological analysis allows the reconstruction of local vegetation, climatic conditions, and subsistence practices. The

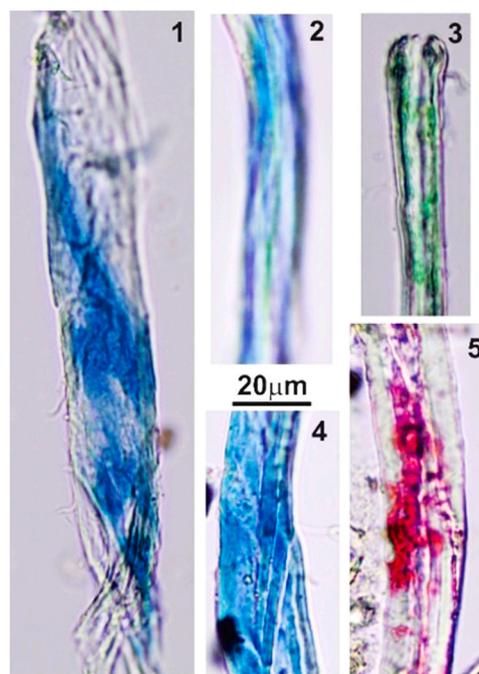


Fig. 14. The cotton fiber dyed in blue (1), flax fibers dyed in light blue (2, 3, 4), and flax fiber dyed in red (5) found on the chest of the individual buried in Burial #1 (according to E. Kvavadze).

⁷ There were no pollen or microfauna elements in the soil sample from the Grave 5.

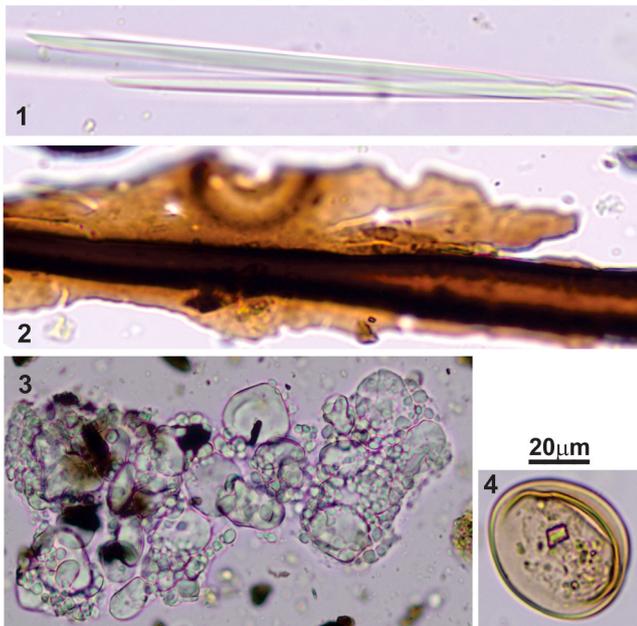


Fig. 17. Enterobius egg and other non-palynological remains found in Burial 2: 1 - Bone salt crystal; 2 - Pine bark cell; 3 - Wheat starch; 4 - Enterobius parasite egg (according to E. Kvavadze).

enables the inference of agricultural and pastoral activities undertaken by the population. Such integrated data contribute not only to paleoenvironmental reconstructions but also to interpretations of diet, medicinal practices, and broader aspects of daily life in past societies.

Grave 1 contained a limited number of pollen and spore remains (Table 2). Nevertheless, these reveal elements of local forest vegetation, including pine (*Pinus*), common hornbeam (*Carpinus betulus*), zelkova (*Zelkova carpinifolia*), and mountain ash (*Sorbus*), along with spores of forest ferns (Table 2). Numerous parenchymal cells from both coniferous

and broad-leaved species further corroborate the presence of nearby forested areas. The discovery of deer antlers within the abdominal region of the skeleton provides indirect evidence of forest exploitation, reflecting both subsistence and ritual practices. Archaeobotanical data indicate that cereal cultivation was practiced at this time, as evidenced by cereal pollen, starch granules, and phytoliths, alongside weeds typical of cultivated fields, including *Centaurea*, *Polygonum*, and *Convolvulus* (Behre, 1986). Spores of *Glomus*, associated with tilled soils, further confirm agricultural activity (Van Geel, 1998; Kvavadze et al., 2020). Climatic reconstruction suggests a warmer and more humid environment compared with modern conditions, as indicated by thermophilous taxa such as *Zelkova* and *Carpinus* and freshwater algae including *Spirogyra* (Kvavadze and Connor, 2005; Hayrapetian et al., 2025). Comparable palynological data from Kakheti and other regions, including lake and marsh sediment analyses, support this inference, indicating extensive broad-leaved and coniferous forests in eastern Georgia during the Late Bronze and Early Iron Age (Pistkhelauri and Kvavadze, 1997; Connor, 2011). These forests would have supplied essential wood resources, supporting the region's burgeoning metallurgical activities.

Grave 2 dated to the Hellenistic period, yielded a relatively poor arboreal pollen spectrum but nonetheless provides clear evidence for warm and humid climatic conditions (Table 2). Parenchymal cells of pine and broad-leaved species, along with freshwater algae (*Pseudoschizaea*), indicate favorable growth conditions. Spores of mycorrhizal fungi further corroborate elevated humidity. Agricultural activity is evidenced by cereal pollen, starch grains, phytoliths, and abundant *Glomus* spores. These data align closely with palynological results from contemporaneous sites such as Vani, where highly diverse pollen assemblages from 22 samples document extensive agriculture, including cereals, horticulture, viticulture, and the cultivation of warmth-demanding species like olive (*Olea europaea*) (Chichinadze and Kvavadze, 2013). Such evidence indicates that the South Caucasus experienced a milder and more humid climate than today, supporting both crop diversity and complex economic practices.

Grave 3 exhibits a rich palynological spectrum, particularly beneath the skull, reflecting extensive interaction with the surrounding

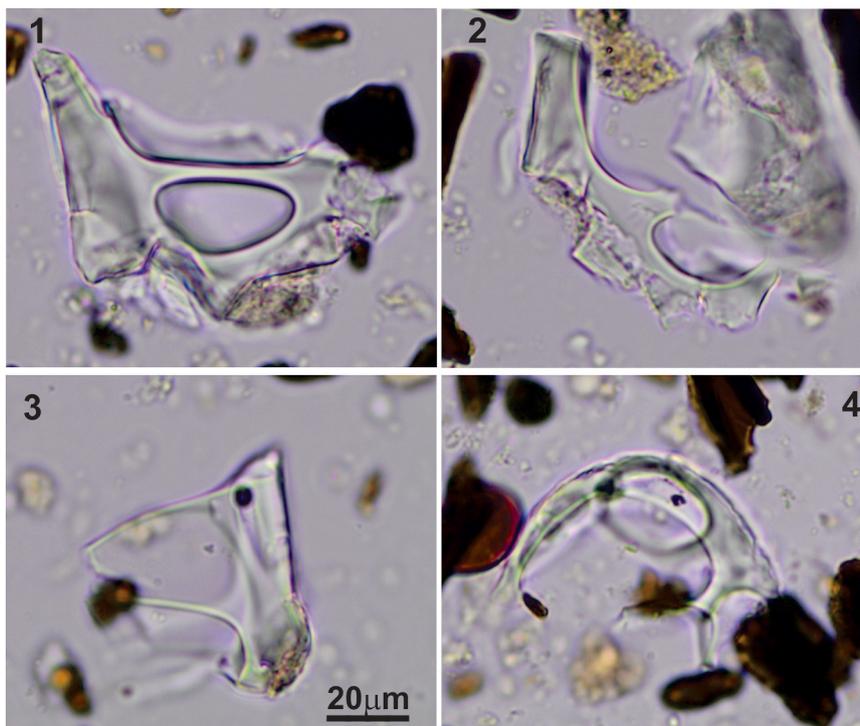


Fig. 18. The remains of volcanic ash found in Grave 2 (according to E. Kvavadze).

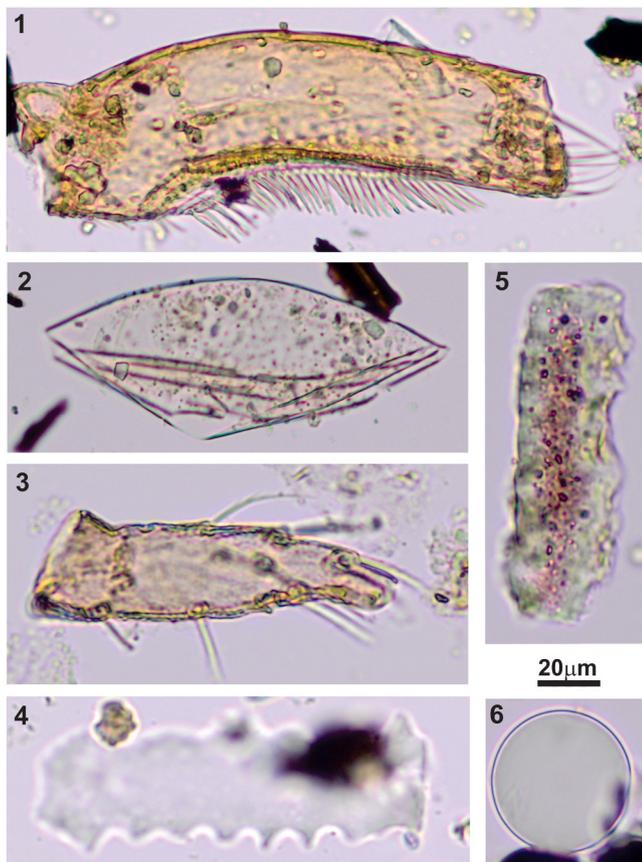


Fig. 19. Non-palynological remains found in Burial 3: 1, 2, 3 - Insect remains; 4, 5 - Phytoliths of wheat; 6 - Wheat starch (according to E. Kvavadze).

environment (Table 2). Forest taxa include common hornbeam (*Carpinus betulus*), oak (*Quercus*), lime (*Tilia*), common walnut (*Juglans regia*), and elm (*Ulmus*), while undergrowth plants comprise hazel (*Corylus*), wild grape (*Vitis sylvestris*), and tree ferns (Polypodiaceae). Agricultural activity, including cereal cultivation, horticulture, and viticulture, is well represented. Climatic conditions are inferred to have been significantly warmer than present, consistent with other palynological studies in the Kvibisi region, which also demonstrate the presence of thermophilous broad-leaved species and residues of olive oil (Kvavadze, 2023; Nakhutsrishvili, 2013). Freshwater algae (*Pseudoschizaeae*) further indicate warm, humid conditions.

Grave 4, dated to the Middle Ages, similarly demonstrates forested surroundings, with pollen from pine (*Pinus*), hornbeam (*Carpinus*), alder (*Alnus*), elm (*Ulmus*), and tree ferns (*Pteridium aquilinum*, Polypodiaceae) (Table 2). Evidence of cereal cultivation and horticulture is present, while freshwater algae and eggs of the liver fluke (*Fasciola hepatica*) suggest warmer and wetter conditions. Comparable parasitological findings have been reported at Early Bronze Age sites such as Ananuri kurgan 3, indicating the persistence of favorable climatic conditions throughout the region. Broader analyses suggest that these Medieval climate optimums peaked in the 10th century A.D., corresponding to the Medieval Warm Period (Connor and Kvavadze, 2008, 2014; Kvavadze and Connor, 2005; Hayrapetiyani et al., 2025; Thomas and Thomas, 2000; Bradley et al., 2003).

Graves 6–8 present higher pollen concentrations and consistently reflect warm and humid conditions (Table 2). Here a child burial, shows abundant lime (*Tilia*) pollen, parenchymal cells of broad-leaved species, and sporadic pine cells. Freshwater algae (*Pseudoschizaea*, *Spirogyra*) and fungal spores further support a warm and humid microclimate. Cereal pollen, starch granules, and phytoliths indicate intensive agriculture, while pollen of melliferous and medicinal plants points to therapeutic

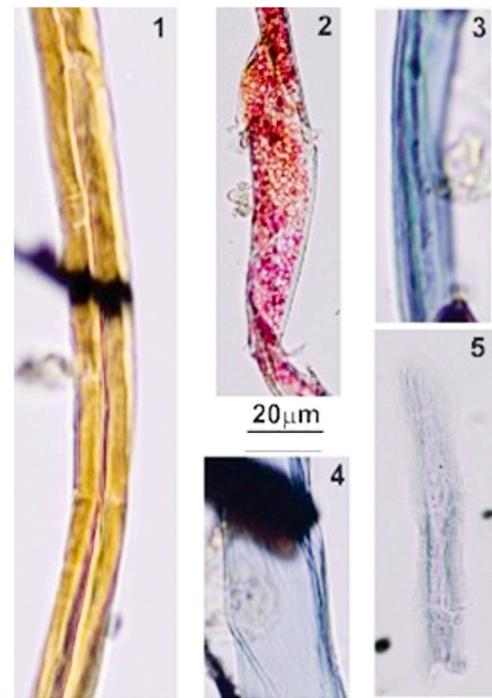


Fig. 20. Fibers of dyed flax and cotton fabrics found in Burials #4, #7 and #8: 1, 3, 5 - Flax fibers; 2, 4 - Cotton fibers (according to E. Kvavadze).

practices and bee-related activities. Graves 7 and 8, contemporary with Grave 6, similarly exhibit thermophilous forest species such as lime and hornbeam, spores of forest ferns, and cereal microremains. Abdominal and pelvic analyses reveal the consumption of wheat, nuts, and honey, while nettle pollen suggests medicinal use. The presence of eggs from parasitic worms, including pinworm (*Enterobius*) and *Capillaria*, corroborates the persistence of helminthic infections under these climatic conditions. Textile fibers, particularly dyed linen and cotton in blue and light blue, suggest the presence of high-status clothing, consistent with social stratification evidenced in other medieval burials at Samshvilde and related sites (Bitadze et al., 2011; Bakhtadze et al., 2023).

5.2. Medicinal herbs and most common diseases

The palynological analysis of the Samshvilde graves provides important insights into medicinal practices, health conditions, diet, and textile use across multiple periods. In Grave 1, dated to LB-Iron Age, pollen from medicinal herbs was detected in the abdominal region. These included yarrow (*Achillea*), chicory (*Cichorioideae*), and rowan (*Sorbus*), all traditionally employed in the treatment of gastrointestinal disorders (Alarcol et al., 2015; Fortini et al., 2016; Sary et al., 2020). Additionally, deer antler remains were present, which are known for comparable therapeutic properties (Orasoy et al., 2024; Nazarbek et al., 2024), suggesting a combination of medicinal and ritual interventions.

In Grave 2, the abdominal region contained seven taxa, six of which belong to the Asteraceae family: centaury (*Centaurea*), aster (*Aster*), rough cocklebur (*Xanthium*), plumeless thistle (*Carduus*), yarrow (*Achillea*), chicory (*Cichorioideae*), and golden hawk's-beard (*Crepis aurea*). These plants are traditionally recognized for their antioxidant, antimicrobial, and anti-inflammatory properties and were primarily used to address gastrointestinal ailments (Said et al., 2002; Michalevska et al., 2012; Martkoplshvili and Kvavadze, 2015). The presence of *Convolvulus* indicates potential treatment for dermatological conditions (Jabeen et al., 2010; Leto et al., 2013), suggesting the individual may have combined topical remedies, including the application of volcanic ash, with oral herbal treatments.

Grave 3 also contained a diverse assemblage of medicinal plants

beneath the skull and within the abdominal region. Identified taxa included *Plantago*, *Achillea*, *Apium*, *Centaurea*, *Rumex*, *Xanthium*, and *Polypodium aquilinum*. Most of these species were traditionally employed to treat gastrointestinal disorders (Duke et al., 2002; Rai et al., 2011; Quattrocchi, 2012). Notably, *Polypodium aquilinum* was used in ethnopharmacology for rheumatism, whereas *Rumex* exhibits anti-diarrheal properties (Eissa et al., 2013).

In Grave 4, where the deceased was infected with *Enterobius*, pollen from alder (*Alnus*), plantain (*Plantago*), plumeless thistle (*Carduus*), and bracken fern (*Pteridium aquilinum*) was detected. Alder and plantain are documented in traditional medicine for treating helminthiasis and gastrointestinal disorders (Quattrocchi, 2012; Eissa et al., 2013; Tetic et al., 2013; Menale and Mouio, 2014), while bracken fern continued to serve in rheumatism therapy (Fortini et al., 2016).

Grave 6 provides evidence of helminthiasis treated with wormwood (*Artemisia*), historically used for intestinal parasites (Hayta et al., 2014; Bussman et al., 2016; Martkoplshvili and Kvavadze, 2015). Other plants such as *Ranunculus*, *Apium*, and *Centaurea* were employed against diarrhea, while lime (*Tilia*) functioned as a remedy for fever, colds, and as an antiseptic (Demiray et al., 2009; Güler et al., 2015; Kvavadze et al., 2020).

In Grave 7, pollen from *Malva* was notable for its analgesic and antibacterial properties, potentially mitigating abdominal pain associated with helminth infection (Bouriche et al., 2011; Fortini et al., 2016). Additional medicinal plants from the Asteraceae family were also detected, indicating treatment for gastrointestinal disorders.

Grave 8 contained a wide range of medicinal plant pollen in the abdominal and femoral regions, including *Ilex*, *Sorbus*, *Tilia*, *Achillea*, *Artemisia*, *Aster*, and *Cichorioideae*. *Ilex* and *Sorbus* appear here for the first time in this context; *Ilex* is traditionally used against helminthiasis and diarrhea (Alikaridis, 1987; Al-Waili, 1988), whereas *Sorbus* provides antioxidants and therapeutic effects for diabetes and rheumatism (Baillia et al., 2016; Sary et al., 2020). The remaining taxa exhibit antiseptic or gastrointestinal protective properties (Baillia et al., 2016).

These findings collectively demonstrate that, irrespective of age, individuals at Samshvilde suffered from a range of health conditions, including helminthiasis, rheumatism, diabetes, and gastrointestinal disorders. Helminth infections were absent only in Grave 1, while Grave 2 contained eggs of *Enterobius*, a globally prevalent parasite associated with intestinal, hepatic, and appendiceal complications (Williams and Dixon, 1988; Brewster, 1989; Mondou and Gnepp, 1989; Deshpande, 1992). By the Middle Ages, helminthiasis in the region expanded to include *Capillaria* and *Fasciola hepatica*, likely facilitated by the warm and humid climate, as well as population movements during periods of conflict, such as the “Great Turkish Invasion.” Chronic stress from frequent warfare may have exacerbated susceptibility to disease, consistent with contemporary studies on the negative impact of stress on health (Glaser and Kiecolt-Glaser, 2005; Rosenthal and Alter, 2012; Shahid Zafar et al., 2021).

Dietary reconstructions indicate a largely cereal-based diet, primarily wheat, supplemented by honey, nuts, walnuts, and grapes. Meat consumption appears limited, evidenced by bone salt crystals in both archaeological vessels and coprolites (Martkoplshvili and Kvavadze, 2015; Kvavadze et al., 2020, 2022), with traces detected only in Graves 2 and 4. Evidence of cattle husbandry is corroborated by the presence of dung fungi, particularly *Sordaria*, associated with ruminant excrement (Van Geel and Artroot, 2006).

Textile analyses reveal a predominance of flax fibers across all periods studied (Table 2), with sporadic traces of cotton and rare hemp cloth. Wool fibers were detected solely in Grave 6, while silk remains were absent, likely due to preservation biases (Chichinadze and Kvavadze, 2024; Kvavadze and Chichinadze 2025). Textile coloration, particularly blue-dyed linen and cotton, suggests markers of social status and craft specialization within the community.

6. Conclusion

The multidisciplinary study of the Samshvilde graves offers important insights into the environment, lifeways, health, and cultural practices of past populations. While the number of graves investigated remains limited, the combined bioarchaeological, archaeological, and palynological analyses contribute to a more nuanced understanding of ecological, economic, and social conditions across several millennia:

6.1. Archaeological and bioarchaeological significance, human health and traumas

- Long-term strategic occupation: Samshvilde, a naturally defended basalt promontory, was continuously settled from the Early Bronze Age through the medieval period.
- Multidisciplinary insights: research of the archaeological contexts demonstrates the value of integrating archaeological, bioarchaeological, and palynological data to reconstruct past lifeways and environments.
- Mortuary and cultural evidence: The eight investigated graves provide indications of social status, economic practices, and ritual behaviors. Associated grave goods—including vessels, coins, textiles, and deer antlers—may reflect medicinal, symbolic, or status-related functions, though their precise significance requires further contextual interpretation.
- Bioarchaeological analysis identified congenital conditions (e.g., hip dysplasia), degenerative pathologies (osteoarthritis, dental wear), and evidence of chronic physical stress across multiple individuals.
- Perimortem trauma, including sharp- and blunt-force cranial injuries, was common in several burials, indicating violent deaths, likely related to historical incursions, such as Seljuk, Mongol, and Turkish invasions.
- Evidence of long-term care for individuals with congenital or chronic conditions highlights medieval social support systems and communal empathy.

6.2. Palynological significance: climate and environmental conditions, subsistence, economy and medicinal practices

- Palynological data indicate that Samshvilde experienced warmer and more humid conditions than at present in all periods studied. Forests of heat-loving broad-leaved tree species dominated landscapes, supplemented by pine and other coniferous taxa.
- The warm climate facilitated agricultural and horticultural activities, including cereal cultivation, viticulture, and use of medicinal plants.
- Diets were largely cereal-based, dominated by wheat flour and grain products, with honey, nuts, and walnuts consumed less frequently.
- Meat consumption was limited, observed in only two individuals.
- Evidence of cattle breeding is indicated by spores of dung fungi, particularly *Sordaria*, confirming livestock husbandry.
- Widespread helminthiasis is suggested by the presence of *Enterobius*, *Capillaria*, and *Fasciola hepatica* eggs, while pollen from medicinal herbs indicates folk pharmacology targeting gastrointestinal, rheumatic, diabetic, and dermatological conditions.
- Therapeutic practices included the use of deer antlers, volcanic ash, and nettle-based remedies.

6.3. Graves' seasonality, textiles and clothing

- Palynological analyses allowed determination of burial seasons: only one individual was buried during summer; the remaining interments occurred during the cold season.
- Clothing and textile artifacts were predominantly flax-based, with limited cotton and rare hemp fibers. Wool was identified in only one medieval grave.

- Dyed fibers, including light blue, blue, and red, suggest knowledge of textile coloring and may reflect social or economic status.

6.4. Integration of archaeological and environmental data, and broader implications

- The combination of archaeological, bioarchaeological and palynological data enables reconstruction of life histories, causes of death, therapeutic interventions, and aspects of daily life within Samshvilde.
- The data contribute to understanding demographic growth, settlement expansion, and socio-economic organization in the South Caucasus across several millennia.
- Evidence from Samshvilde provides a model for interdisciplinary studies linking archaeology, archaeobiology, and paleoenvironmental research in complex historical landscapes.

Funding Information

Archaeological investigations of the graves at the ancient settlement of Samshvilde were funded by the University of Georgia. The analysis of archaeological, bioarchaeological, and palynological materials recovered during excavations was supported through a research grant from the Scientific Institute of the University of Georgia (Grant: 7/24.09.05.2024). Radiocarbon dating of bioarchaeological remains was conducted at the Accelerator Mass Spectrometry (AMS) Laboratory, University of Arizona, while palynological samples were processed at the Palaeoanthropology and Palaeobiology Research Institute of the Georgian National Museum. The authors gratefully acknowledge the support of these institutions, whose contributions were essential to the successful completion of this project.

CRediT authorship contribution statement

Shota Tvaladze: Writing – review & editing, Methodology, Investigation, Data curation. **Levan Kvakhadze:** Writing – original draft, Methodology, Investigation, Data curation. **Nino Tavartkiladze:** Writing – original draft, Methodology, Data curation. **David Berikashvili:** Writing – original draft, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization. **Eliso Kvavadze:** Writing – original draft, Methodology, Investigation, Conceptualization.

Declaration of Competing Interest

All the authors (listed below) declare that we have no established conflicting financial interests or personal relationships that may have influenced the research presented in this paper.

Acknowledgment

We gratefully acknowledge the support provided during the course of this project. In particular, we wish to thank Ms. Ekaterine Topuria, Vice-Rector of the University of Georgia, Tbilisi; Prof. Tinatin Gudushauri, Director of the School of Arts and Humanities; Prof. Zviad Gabisonia, Director of the Scientific Institute of the University of Georgia; and Ms. Elene Manjgaladze, Manager of the same institute. We also recognize the valuable contributions of PhD candidate Isabelle Coupal and Master's student Marie-Eve Dupuis (University of Montreal) for their bioarchaeological research. The involvement of Dr. Sean Field, who kindly provided detailed edits and comments on the manuscript, was particularly appreciated.

Finally, we express our sincere gratitude to the chief editor of the journal and reviewers of this article, whose constructive feedback and collegial suggestions were invaluable in improving the manuscript.

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