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TÁBIOVÁ, Miriama – BORZOVÁ, Zuzana – VITOVÍČ, Ladislav – CHEBEN, Michal – VOJTEČEK, Marek – LUŠTÍKOVÁ, Lucia – LIESKOVSKÝ, Tibor. The Preservation State of Human Bones From the Early Medieval Burial Ground in Valaliky (Eastern Slovakia) in the Context of Natural Influences. In *Studia Historica Nitriensia*, 2026, Vol. 30, No. 1, p. 3-30, ISSN 1338-7219. DOI: 10.17846/SHN.2026.30.1.3-30.

Archaeological research of the burial ground in Valaliky (Košice-okolie district) uncovered 280 graves from the Early Middle Ages. One of the results of the analyses is an overview of the preservation state of skeletal remains, which is highly variable. This paper aims to identify the factors that influenced the degree of preservation of skeletal remains. It evaluates the influence of biological (age, sex), cultural (several features of the burial rite: depth of the burial pit, presence/absence of a coffin) and natural factors (soil pH, geological and pedological substrate, placement of graves within the local environment). The results of the analyzed sample revealed a statistically significant relationship between the age of the individual and the degree of preservation of skeletal remains, with worse preservation confirmed in juvenile individuals. Gender was not proven to be a significant factor. Another element was the influence of soil pH, but it was reliably demonstrated only in a set of adult individuals. In this case, lower pH values proved to be a negatively influencing factor. Statistically significant relationships were not confirmed among the other variables monitored. The obtained results indicate a combined influence of paleodemographic and environmental factors on the degree of preservation of osteological findings.

Keywords: Burial; Early Middle Ages; Anthropology; Taphonomic Processes; Soil Properties; Geology; Eastern Slovakia;

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Archeologický výskum pohrebiska vo Valalikoch (okres Košice-okolie) odhalil 280 hrobov zo včasného stredoveku. Jedným z výsledkov analýz je prehľad o stave zachovania kostrového materiálu, ktorý je veľmi variabilný. Cieľom tejto práce je identifikovať faktory, ktoré ovplyvnili jeho stupeň zachovania. Hodnotí sa vplyv biologických (vek, pohlavie), kultúrnych (niekoľko znakov pohrebného ritu: hĺbka hrovej jamy, prítomnosť/neprítomnosť rakvy) a prírodných faktorov (pH pôdy, geologický a pedologický substrát, umiestnenie hrobov v lokálnom prostredí). Výsledky analyzovanej vzorky odhalili štatisticky významný vzťah medzi vekom jedinca a stupňom zachovania kostrového materiálu, pričom sa potvrdilo horšie zachovanie u juvenilných jedincov. Pohlavie sa ako významný faktor nepreukázalo. Ďalším elementom bol vplyv pH pôdy, avšak spoľahlivo demonštrovaný len u súbore dospelých jedincov. V tomto prípade nižšie hodnoty pH sa ukázali ako negatívne vplyvajúci činiteľ. Medzi ostatnými sledovanými premennými sa nepotvrdili štatisticky významné vzťahy. Získané výsledky naznačujú kombinovaný vplyv paleodemografických a environmentálnych faktorov na mieru zachovania osteologických nálezov.

Kľúčové slová: pohrebisko; včasný stredovek; antropológia; tafonomické procesy; vlastnosti pôdy; geológia; východné Slovensko;

Introduction

In 2023, the Institute of Archaeology of Slovak Academy of Sciences conducted archaeological research in the cadastral territory of Valaliky, Košice-okolie district, during which a burial ground from the Early Middle Ages was completely uncovered¹. According to research documentation, of the 280 archaeological objects, 16 did not contain human skeletal remains. In the remaining graves, 269 unique osteological finds were identified. One of the results of the analyses is an overview of the state of preservation of the osteological remains, which in this case is highly variable: from strong complete bones, through fragile and fragmented bones, to extremely fragmented bones².

The scientific question, or rather the focus of this paper, is to identify the causes behind the varying preservation state of skeletal remains from the examined burial ground. These may be related to the age and sex of the population buried here. Another group of possible causes for the variable skeletal preservation state can be found in the various manifestations of the burial rite, particularly in the different methods of burial or interment of the bodies in the ground – i.e., if they were placed in coffins or without coffins in organic coating, or if the bodies were interred directly in the ground without any coating³.

Last but not least, the focus was put on analysing several additional aspects of the natural environment that could cause the varying states of skeletal preservation. These include the impact of the variable terrain of the burial site, different geological settings⁴, particularly the varying depths of the burial pits sunk into the substrate. Similarly, the nature of the soil and its specific characteristics, such as soil pH, soil type, and dynamic soil properties (water level fluctuations, soil moisture and texture), could have also influenced the varying state of skeletal preservation⁵.

¹ LUŠTÍKOVÁ, Lucia – GAŠPAR, Adam – VOJTEČEK, Marek – CHEBEN, Michal. „Strategické územie Valaliky“ – germánska osada (VIP1). Výskumná dokumentácia. Archeologický ústav SAV, v.v.i. Unpublished. Košice; Nitra 2024.

² GORDON, C. Claire – BUIKSTRA, E. Jane. Soil pH, bone preservation, and sampling bias at mortuary sites. In *American Antiquity*, 1981, vol. 46, no. 3, pp. 566–571.

³ PÍŠTEKOVÁ, Hana. Tafonomie v archeologickém kontextu. Analýza velkomoravských pohřbů na lokalitě Břeclav-Pohansko-Lesní hrád. Unpublished thesis (Bc.). Brno 2011.; PROKEŠ, Lubomír. Posmrtné změny a jejich význam při interpretaci pohřebního ritu. Brno 2007, pp. 48.

⁴ KALIČIAK, Michal (ed.) – BAŇACKÝ, Vladimír – JANOČKO, Juraj – KAROLI, Stanislav – PETRO, Lubomír – SPIŠÁK, Zoltán – VOZÁR, Jozef – ŽEC, Branislav. Geologická mapa Slanských vrchov a Košickej kotliny – južná časť [online]. Available from: https://www.geology.sk/wp-content/uploads/documents/foto/geol_mapy_50k/25a_Slanske%20vrchy%20a%20Kosicka%20kotlinina.jpg; 15.4.2025.

⁵ HIGH, Kirsty – MILNER, Nicky – PANTER, Ian – PENKMAN, E. H. Kirsty. Apatite for destruction: Investigating bone degradation due to high acidity at Star Carr. In *Journal of Archaeological Science*, 2015, vol. 59, pp. 159–168.; KENDALL, H. Christopher – ERIKSEN, M. H. Anne – KONTOPOULOS, Ioannis – COLLINS, J. Matthew – TURNER-WALKER, Gordon. Diagenesis of archaeological bone and tooth. In *Palaeogeography, Palaeoclimatology, Palaeoecology*, 2018, 491, pp. 21–37.; KIBBLEWHITE, Mark – TÓTH, Gergely – HERMANN, Tamás. Predicting the preservation of cultural artefacts and buried materials in soil. In *Science of the Total Environment*, 2015, 529, pp. 249–263. NIELSEN-MARSH, Christina – GERNAYE, Angela – TURNER-WALKER, Gordon – HEDGES, Robert – PIKE, Alistair – COLLINS, Matthew. The chemical degradation of bone. In COX, Margaret – MAYS, Simon (eds.). *Human Osteology – In Archaeology and Forensic Science*. Cambridge 2000, pp. 439–454.; TODISCO, Dominique – MONCHOT, Hervé. Bone weathering in a periglacial environment: The Tayara Site (KbFk-7). Qikirtaq Island, Nunavik (Canada). In *Arctic*, 2007, vol. 61, no. 1, pp. 87–101.

By analysing the individual aspects of the varying state of human bones preservation from the Valaliky burial ground, an attempt will be made to identify dependencies that can be applied also in future taphonomic research at other burial grounds, thereby enabling predictions about the possible use of specific complementary biological methods⁶.

Natural Condition at the Site

According to the geomorphological division of Slovakia⁷, later refined by Kočický and Ivanič⁸, the examined burial site is located in the southern part of the Košice Basin, in the Košická rovina Plain subunit (Figure 1: A, B). The Košice Basin belongs to the Lučenec-Košice Depression area, which is a part of the Inner Western Carpathians subprovince and the Western Carpathians province. These belong to the Carpathian subsystem and Alpine-Himalayan system.

Regarding the morphostructural characterisation, the studied area is a part of the Lučenec-Košice Depression morphostructure, more precisely of its distinctive negative morphostructures – grabens. In terms of the main types of erosion-denudation relief of the Western Carpathians, this area has the character of a basin hilly land. The relief of the area is characterized by generally low dissection, and is formed mainly by fluvial and partly by aeolian landforms, especially wide floodplains, terraces, alluvial fans and cones⁹. According to the morphological-morphometric typification of the relief¹⁰, the studied area lies in a region of horizontally and vertically dissected plains.

The elevation of the Košická rovina Plain ranges from 162 m to 250 m above sea level (a.s.l.), with the burial ground located at 194 m a.s.l. The terrain slope generally ranges up to 2.5°, with steeper sections occurring only sporadically¹¹. From a more detailed perspective, the river terrace treads have a slope of up to 1°, while in areas where the relief steepens along the terrace risers, the slope angles increases to 3 – 5°, and locally even higher.

The burial ground is located on the right side of the Hornád River valley, near its confluence with the Torysa River (5.4 km as the crow flies), 10 km south of the city of Košice and west of the village of Valaliky. To the east of the site, at a distance of 200 – 300 m, flows the minor Valalický Canal. Considering the flat character of the broader surrounding area (vertical relief dissection up to 30 m), the burial ground lies on a Pleistocene river terrace on a relatively prominent elevation compared to the low terrace to the east (height difference 6.5 m) the Hornád floodplain (12 m) and the Hornád riverbed (14 m). Conversely,

⁶ see NIELSEN-MARSH, Christina – SMITH, I. Colin – JANS, M. E. Miranda – NORD, Anders – KARS, Henk – COLLINS, J. Matthew. Bone diagenesis in the European Holocene II: taphonomic and environmental considerations. In *Journal of Archaeological Science*, 2007, vol. 34, pp. 1523–1531.

⁷ MAZÚR, Emil – LUKNIŠ, Michal. Geomorfologické jednotky (1 : 500 000). In *Atlas Slovenskej socialistickej republiky*. Bratislava 1980, pp. 54–55.

⁸ KOČICKÝ, Dušan – IVANIČ, Boris. Geomorfologické členenie Slovenska [online]. Bratislava: Štátny geologický ústav Dionýza Štúra, 2011. Available from: https://www.geology.sk/new/sites/default/files/media/geois/PrehľadneMapy/GM_mapa.pdf; 27.3.2025

⁹ MAZÚR, Emil – ČINČURA, Juraj – KVITKOVIČ, Jozef. Geomorfológia (1 : 500 000). In *Atlas Slovenskej socialistickej republiky*. Bratislava 1980, pp. 46–47.

¹⁰ TREMBOŠ, Peter – MINÁR, Ján. Morfológicko-morfometrické typy reliéfu (1 : 500 000). In *Atlas krajiny Slovenskej republiky*. Bratislava – Banská Bystrica 2002, p. 91.

¹¹ ZVARA, Igor – GAŠPAR, Anton. Sklon reliéfu (1 : 1 000 000). In *Atlas krajiny Slovenskej republiky*. Bratislava – Banská Bystrica 2002, pp. 89.

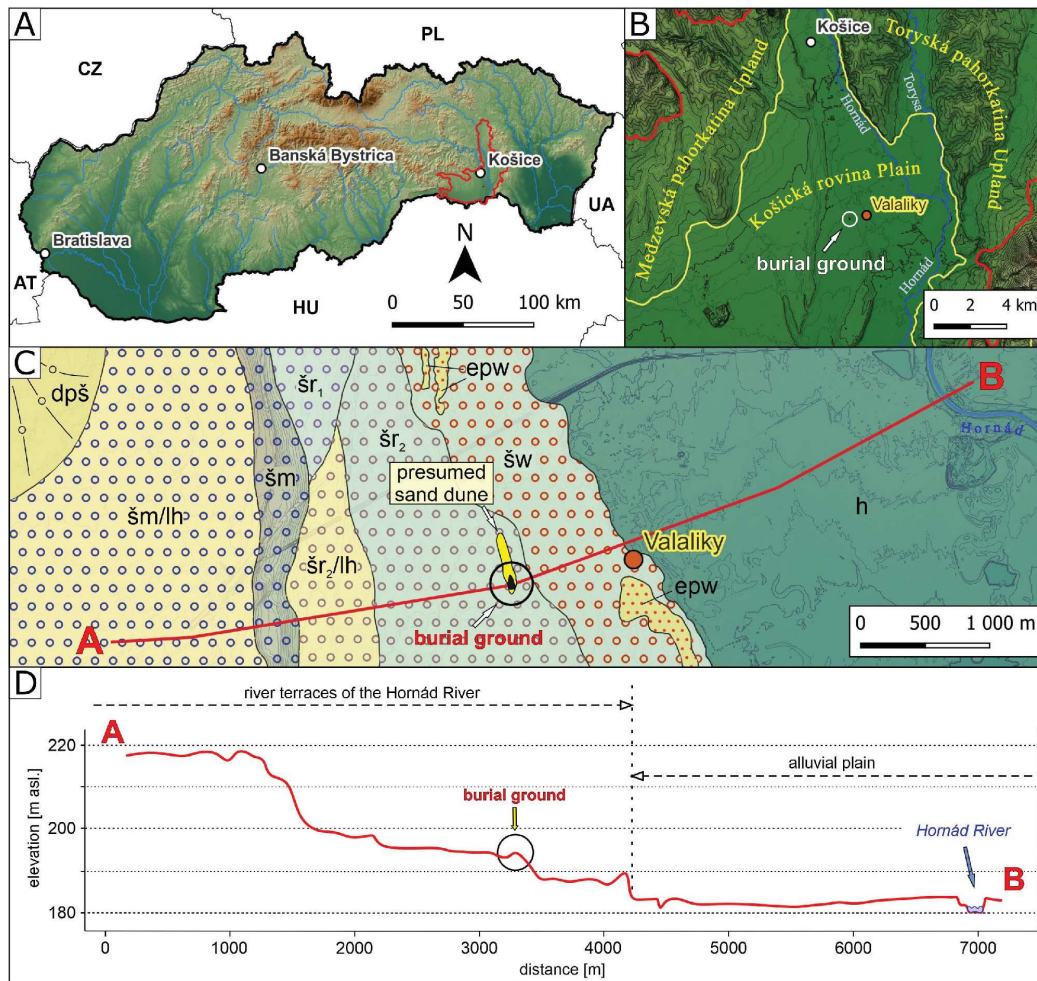


Fig. 1. Natural condition at the site: A – Position of the Košice Basin within Slovakia. B – Position of the burial ground in the context of the southern part of the Košice Basin. The red line marks the boundaries of the Košice Basin, the yellow line marks the boundaries of its subunits. C – Location of the burial ground on the basis of a geological map (KALIČIAK – BAŇACKÝ – JANOČKO – KAROLI – PETRO – SPIŠÁK – VOZÁR – ŽEC, *Geologická mapa Slanských vrchov...*, modified). The red line (marked A-B) represents the profile line of the cross-section shown in section D. Legend to the geological map: šm/lh: fluvial sediments: sandy gravels covered with loessy loams (Mindel, Middle Pleistocene), šm: fluvial sediments: sandy gravels (Mindel, Middle Pleistocene), šr₁: fluvial sediments: sandy gravels (Early Riss, Middle Pleistocene), šr₂: fluvial sediments: sandy gravels (Late Riss, Middle Pleistocene), šr₁/lh: fluvial sediments: sandy gravels covered with loessy loams (Late Riss, Middle Pleistocene), šw: fluvial sediments: sandy gravel (Würm, Upper Pleistocene), epw: aeolian sediments: sands with short transportation (Würm, Upper Pleistocene), dps: deluvial-proluvial sediments: sandy loams with gravels (Holocene/Pleistocene), h: fluvial sediments: loams, sands and clays (Holocene). D – Cross-section of the right side of the Hornád valley marking the location of the burial ground.

compared to the older and higher-located river terrace situated 1 800 m to the west, the burial ground lies 25 m lower (Figure 1: C, D).

The sedimentary fill of the Košická rovina Plain in this section consists of the Stretava Formation (Lower-Middle Sarmatian) composed of clays, sandy clays, clayey sands, and layers of gravel, locally with intercalations of redeposited rhyolite tuffs¹². The Quaternary cover at the burial site and its surroundings is formed by Pleistocene fluvial deposits of the Hornád River, which are part of its terrace system. In this section of the valley, it is preserved in the form of four river terraces (upper, two middle and lower terraces) from the Middle to Upper (Late) Pleistocene (Figure 1: C). This is river gravel-sand material deposited during the cold periods of the Pleistocene, which is in certain areas covered with finer (sandy to dusty) aeolian deposits. The lowest parts of the Hornád valley are filled with valley-bottom fill from the Last Glacial Period, which protrudes to the surface along the edge of the floodplain in the form of a low terrace. In the inundation zone, the valley-bottom fill was eroded and overlain by fine Holocene alluvial deposits¹³.

In the vicinity of the examined site, Haplic Luvisols, Eutric Cambisols to Dystric Cambisols have developed¹⁴.

According to the runoff regime, the area belongs to an upland-lowland region with high water levels from February to April and a significant secondary increase of water bearing in late autumn and early winter. In this section, the Hornád River exhibits a snowfall-rainfall runoff regime with the lowest average monthly flow during January to February and also during September to October, and high water levels during March to May. The secondary increase of water bearing in late autumn and early winter is moderately significant¹⁵. The average annual precipitation in this area ranges from 600 mm to 700 mm, and it belongs to a warm climatic region and a warm, moderately dry subregion¹⁶.

Archaeological Background

The cadastral territory of Valaliky has been inhabited since prehistoric times. The oldest finds can be dated back to the Neolithic and Eneolithic periods¹⁷. There is evidence of a burial ground from the Bronze Age¹⁸ as well as other traces of settlement in several

¹² KAROLI, Stanislav – KALIČIAK, Michal – ŽEC, Branislav – DUBÉCIOVÁ, A. – ZLINSKÁ, Adriena. Neogén. In KALIČIAK, Michal et al. (eds.). *Vysvetlivky ku geologickej mape Slanských vrchov a Košickej kotliny – južná časť 1:50 000*. Bratislava 1996, p. 42.

¹³ KALIČIAK – BAŇACKÝ – JANOČKO – KAROLI – PETRO – SPIŠÁK – VOZÁR – ŽEC, *Geologická mapa Slanských vrchov...*

¹⁴ ŠÁLY, Rudolf – ŠURINA, Bohumil. *Pôdy*. In *Atlas krajiny Slovenskej republiky*. Bratislava; Banská Bystrica 2002, p. 107.

¹⁵ ŠIMO, Eduard – ZAŤKO, Martin. *Typy režimu odtoku*. In *Atlas krajiny Slovenskej republiky*. Bratislava; Banská Bystrica 2002, p. 103.

¹⁶ LAPIN, Milan – FAŠKO, Pavel – MELO, Marián – ŠŤASTNÝ, Pavel – TOMLAIN, Ján. *Klimatické oblasti*. In *Atlas krajiny Slovenskej republiky*. Bratislava; Banská Bystrica 2002, p. 95.

¹⁷ PASTOR, Jozef. *Sídliská z počiatkov nášho letopočtu na východnom Slovensku*. In *Archeologické Rozhľady*, 1960, vol. 12, pp. 361–366.; PASTOR, Jozef. *Pohrebisko zo staršej doby bronzovej v Košianoch*. In *Študijné Zvesti AÚ SAV*, 1962, vol. 9, pp. 63–80, 63.; ŠIŠKA, Stanislav. *K počiatkom kultúry s kanelovanou keramikou na východnom Slovensku*. In *Slovenská archeológia*, 1966, vol. 14, no. 1, pp. 49–76, 55.

¹⁸ PASTOR, *Pohrebisko zo staršej doby bronzovej...*, pp. 63–80.

locations within the village¹⁹. The village was also inhabited during the subsequent Hallstatt, La Tène, and Roman periods²⁰. Another burial ground was excavated in Valaliky-Všechsvätých, in the Koscelné location. It was found to be a necropolis from the period of the Avar Khaganate²¹. From the later Middle Ages, there are several collected finds, as well as traces of settlement in the form of remains of settlement features²² and the remains of another burial ground²³. Finds of a more recent date can be dated to the 18th and 19th centuries²⁴.

The burial ground in question was discovered during rescue excavations in the southern part of the surveyed area. A total of 280 features were documented. The graves within the burial ground were arranged in rows and predominantly oriented in an east-west direction with slight deviations. The bodies were laid in the burial pits in a stretched position on their backs with their lower limbs straightened and their upper limbs in various positions: alongside the body, crossed over the pelvis, on the chest, etc. In several graves, the skeletons were laid in various crouched positions, lying on their sides with bent legs. Within the burial ground, two equestrian graves were also found, i.e., graves containing not only human skeletons but also partial burials of horses. Archaeological finds have been recorded from 128 graves. These include everyday objects, weapons and equipment, craft tools, jewellery and clothing accessories, ceramic vessels, and animal bones²⁵. Based on several elements of the burial rite, as well as the nature of the material culture from the graves, it can be assumed that this is an early medieval necropolis, or an Old Hungarian burial ground.

Already during the archaeological survey of the burial ground, it became evident that the state of preservation of the graves and skeletons varied considerably – from nearly completely and partially decomposed to very well preserved²⁶. This observation was also confirmed during a detailed anthropological analysis²⁷.

¹⁹ KLIMKOVICS, Béla. Kimutatás, azon ajándéktárgyakról, melyekkel a felsőmagyarországi muzeum gyűjteményei az 1884. évben gyarapodtak. In Felsőmagyarországi Múzeum-Egylet hatodik évkönyve. Kassa 1885, pp. 88-112, 89.; PASTOR, Sídlišká z počiatkov nášho letopočtu..., p. 361.; PASTOR, Pohrebisko zo staršej doby bronzovej..., p. 63.

²⁰ LAMIOVÁ-SCHMIEDLOVÁ, Mária. Römerzeitliche Siedlungskeramik in der Südoslowakei. In Slovenská archeológia, 1969, vol. 17, pp. 403-501, 456.; LUŠTÍKOVÁ – GAŠPAR – VOJTEČEK – CHEBEN, „Strategické územie Valaliky“..., pp. 5-6.; PASTOR, Sídlišká z počiatkov nášho letopočtu..., pp. 361-366.; PASTOR, Pohrebisko zo staršej doby bronzovej..., pp. 63-80.; MALEC, Juraj – MÜLLEROVÁ, Mária – TRNKUS, Lukáš. Záchranný archeologický výskum vo Valalikoch. In Archeologické výskumy a nálezy na Slovensku v roku 2015, Nitra 2020, pp. 102-104.

²¹ ZÁBOJNÍK, Jozef – BÉREŠ, Július. Pohrebisko z obdobia avarského kaganátu vo Valalikoch-Všechsvätých. Nitra 2016, pp. 294.

²² LUŠTÍKOVÁ – GAŠPAR – VOJTEČEK – CHEBEN, „Strategické územie Valaliky“..., p. 6.; MALEC – MÜLLEROVÁ – TRNKUS, Záchranný archeologický výskum vo Valalikoch..., pp. 102-103.

²³ PASTOR, Jozef. Príspevky ku košickému praveku. In Sborník Muzeálnej slovenskej spoločnosti, 1949-1951, 43-45, pp. 179-184, 179-180.

²⁴ MALEC – MÜLLEROVÁ – TRNKUS, Záchranný archeologický výskum vo Valalikoch..., pp. 102-104.

²⁵ LUŠTÍKOVÁ – GAŠPAR – VOJTEČEK – CHEBEN, „Strategické územie Valaliky“..., p. 15.

²⁶ LUŠTÍKOVÁ – GAŠPAR – VOJTEČEK – CHEBEN, „Strategické územie Valaliky“..., p. 15.

²⁷ TÁBIOVÁ, Miriama. Odborný antropologický posudok. Prvá etapa hodnotenia: hroby 2-106. Unpublished. Nitra 2024.; TÁBIOVÁ, Miriama. Odborný antropologický posudok. Druhá etapa hodnotenia: hroby 107-204. Unpublished. Nitra 2024.; TÁBIOVÁ, Miriama. Odborný antropologický posudok. Tretia etapa hodnotenia: hroby 205-260. Unpublished. Nitra 2025.; TÁBIOVÁ, Miriama. Odborný antropologický po-

Material and Methods

The analyses were applied to skeletal remains of 269 individuals. The selection of anthropological methods was chosen accordingly to the character of the research. The estimation of sex as male, probable male (male?), female, probable female (female?), and indifferent, was based on the evaluation of sexual characteristics on the pelvis and skull²⁸. For individuals whose sex could not be estimated, we list the sex as indeterminate. For the purposes of analysis, age was estimated as juvenile (up to 20 years) and adult²⁹. To identify the state of preservation of the skeletal remains, the description system of five groups by³⁰ C. C. Gordon and J. E. Buisstra was applied, ranging from strong complete bones through fragile, fragmented, and extremely fragmented bones, to bone meal.

Strong complete bones remained intact and show no visible signs of taphonomic damage. Fragile bones comprise remains in a fragmentary state that nevertheless allows partial reconstruction. Marginal portions and epiphyses frequently exhibit signs of deterioration or destruction. The category of fragmented bones includes broken and fragmented remains that can still be attributed to particular skeletal elements; however, their reconstruction requires considerable effort. In these cases, the bones are heavily damaged, often to the extent that their terminal parts are no longer clearly identifiable or reconstructable. Cranial bones may sometimes be refitted sufficiently to allow the measurement of several

sudok. Štvrtá etapa hodnotenia: hroby 261-315. Unpublished. Nitra 2025.; TÁBIOVÁ, Miriama. Odborný antropologický posudok. Piata etapa hodnotenia: hroby 316-378. Unpublished. Nitra 2025.

²⁸ ACSÁDI, György – NEMESKÉRI, János. History of human lifespan and mortality. Budapest 1970, pp. 362.

²⁹ BROOKS, Sheilagh – SUCHHEY, M. Judy. Skeletal age determination based on the os pubis: A comparison of the Acsádi-Nemeskéri and Suchey-Brooks methods. In *Human Evolution*, 1990, 5(3), pp. 227–238.; BUIKSTRA, E. Jane – UBELAKER, H. Douglas. Standards for Data Collection from Human Skeletal Remains. Arkansas 1994, pp. 206.; FEREMBACH, Denise – SCHWIDETZKY, Ilse – STLOUKAL, Milan. Recommendations for age and sex diagnoses of skeletons. In *Journal of Human Evolution*, 1980, 9, pp. 517–549.; FLECKER, Hugo. Roentgenographic observations of the times of appearance of epiphyses and their fusion with the diaphyses. In *Journal of Anatomy*, 1932, 67(1), pp. 118–164.; GILBERT, B. Miles – MCKERN, W. Thomas. A method for aging the female os pubis. In *American Journal of Physical Anthropology*, 1973, 38(1), pp. 31–38.; LOVEJOY, C. Owen. Dental wear in the Libben population: Its functional pattern and role in the determination of adult skeletal age at death. In *American Journal of Physical Anthropology*, 1985, 68(1), pp. 47–56.; LOVEJOY, C. Owen – MEINDL, S. Richard – PRYZBECK, R. Thomas – MENSFORTH, P. Robert. Chronological metamorphosis of the auricular surface of the ilium: A new method for the determination of adult skeletal age at death. In *American Journal of Physical Anthropology*, 1985, 68(1), pp. 15–28.; MCKERN, W. Thomas – STEWART, D. Thomas. Skeletal Age Changes in Young American Males, Analyzed from the Standpoint of Age Identification. Natick. Technical Report EP-45, Environmental Protection Research Division, Quartermaster Research and Development Centre, U.S. Army. Massachusetts 1957, pp. 192.; MEINDL, S. Richard – LOVEJOY, C. Owen. Ectocranial suture closure: A revised method for the determination of skeletal age at death based on the lateral-anterior sutures. In *American Journal of Physical Anthropology*, 1985, 68(1), 57–66.; OSBOURNE, L. Daniel – SIMMONS, L. Tal – NAWROCKI, P. Stephen. Reconsidering the auricular surface as an indicator of age at death. In *Journal of Forensic Sciences*, 2004, 49, 905–911.; SCHWARTZ, H. Jeffrey. Skeleton Keys. An Introduction to Human Skeletal Morphology, Development, and Analysis. Oxford 2007, pp. 205.; STLOUKAL, Milan – HANÁKOVÁ, Hana. Die Länge der Längsknochen altslawischer Bevölkerungen unter besonderer Berücksichtigung von Wachstumsfragen. In *Homo*, 1978, 29 (1), pp. 53–69.; TODD, W. Thomas. Age changes in the pubic bone. I. The male white pubis. In *American Journal of Physical Anthropology*, 1920, 3(3), pp. 285–334.; TODD, W. Thomas. Age changes in the pubic bone. In *American Journal of Physical Anthropology*, 1921, 4(1), pp. 1–70.; VLČEK, Emanuel. Metodika určování zubního věku podle stupně mineralizace chrupu v historické antropologii a paleoantropologii. In *Stomatologické zprávy*, 1994, vol. 35, no. 3, pp. 30–39.

³⁰ GORDON – BUIKSTRA, Soil pH..., pp. 588–589.

dimensions, whereas facial bones are often too damaged for reliable reconstruction. The fourth category, extremely fragmented bones, includes remains that are almost impossible to reconstruct, with very limited potential for the collection of metric data or the observation of pathological lesions. The final category consists of bone meal, represented only by powdery traces of human remains preserved as dust imprints on the bottoms of grave pits³¹. Such remains cannot be evaluated osteologically and therefore does not permit any meaningful analysis. For this reason, this category was not included in the evaluation, as the remains were not available for analysis in a form suitable for osteological study. Recent bone fragmentation and the presence of grave goods were not taken into account in the evaluation of the skeletal remains preservation while answering the question posed in this paper. Statistica software³² was used for statistical data processing, testing of normality of distribution and calculation of correlation coefficients. After verifying the assumption of normality of data distribution, non-parametric statistical methods were applied in cases where this assumption was not met, namely the χ^2 test of independence, Spearman's correlation coefficient and Mann-Whitney U test. For a simpler statistical evaluation of pH, the values for female and probable female and male and probable male were unified in the calculations. Individuals with an indeterminate sex and juvenile individuals were not included in the statistical evaluation of sex and state of preservation.

In the analysis of the burial rite, attention was focused on observing the position of the site in relation to the surrounding terrain, and on the observation of the burial pit's depth. This was calculated based on the difference between the maximum and minimum elevation, according to the information from the site report³³.

Special modification of the burial pit, which may also indicate possible burial in a coffin, was assessed on the basis of a different layer of loam at the bottom of the grave, or even by the presence of traces of wood³⁴.

Information about the geological settings of the studied site was obtained from several sources. The primary source was a regional geological map at a scale of 1 : 50,000³⁵, which provided basic information, especially about Quaternary deposits. Given the scale of the map and its relatively low level of detail, further knowledge was obtained through field documentation of sedimentary exposures (outcrops) directly during archaeological research. During a shaft excavation macroscopic identification of sediments was performed. Due to the spatially limited excavation of the burial grounds, GIS tools and a detailed digital terrain model DTM 5.0 (ÚGKK SR), or rather its modified derivative, was subsequently used to delineate the presumed boundaries of the identified sand dune. The soil properties of the studied site and its immediate surroundings were drawn from several sources. To obtain a broader picture of soil properties, the Soil map of Slovakia³⁶ as well as information provided by bonited soil-ecological units³⁷ were used. Information on soil properties

³¹ GORDON – BUIKSTRA, Soil pH..., pp. 588-589.

³² StatSoft, Inc. (2014). STATISTICA (data analysis software system), version 12. <http://www.statsoft.cz>.

³³ LUŠTÍKOVÁ – GAŠPAR – VOJTEČEK – CHEBEN, „Strategické územie Valaliky“...

³⁴ LUŠTÍKOVÁ – GAŠPAR – VOJTEČEK – CHEBEN, „Strategické územie Valaliky“..., p. 9.

³⁵ KALIČIAK – BAŇACKÝ – JANOČKO – KAROLI – PETRO – SPIŠÁK – VOZÁR – ŽEC, Geologická mapa Slanských vrchov...

³⁶ ŠÁLY – ŠURINA, Pôdy..., p. 107.

³⁷ DŽATKO, Michal – SOBOCKÁ, Jaroslava – GRANEC, Martin – BEZÁK, Pavol. Príručka pre používanie máp pôdnoekologických jednotiek. Bratislava 2009, pp. 101.

were also obtained from the Geochemical Atlas of the Slovak Republic³⁸, which provided information on selected soil properties (e.g., soil type, pH/H₂O) from more detailed point database. Additionally, a pedological survey conducted in connection with the planned construction project at the site³⁹ was used as well.

Soil pH values were determined in the Geoanalytical Laboratory of the State Geological Institute of Dionýz Štúr. Thirty soil samples from the immediate vicinity of the skulls were selected for analysis, which were taken during archaeological research and subsequently during the cleaning of the osteological remains. Given that these are archaeological remains several centuries old, it is assumed that the soil pH in the area of the skull and its surroundings has already stabilized at the same values, which are initially more acidic and later more alkaline⁴⁰. The analyzed samples came from the context of 24 adult individuals and six juvenile individuals. The adult group was represented by 12 male and probably male individuals, 10 female and probably female individuals and two individuals of indeterminate sex, while the skeletal remains were found in various degrees of preservation. The selection of samples was carried out from graves no. 2–204, as only these graves had been anthropologically processed at the time of sampling⁴¹. The selection was made so that all categories of skeletal remains preservation, gender and age were represented in the set. The pH was evaluated electrochemically using the STN EN ISO 10390 methodological standard⁴².

Theories and Reasoning

The osteological remains from the examined burial ground exhibits varying states of preservation, ranging from fragmented or partially preserved skeletons to well-preserved skeletons (Figure 2 as example). The aim of the analyses was to determine the causes that could have led to this condition.

It is expected that during their lifetime, individuals are exposed to various environmental influences that may be reflected in the chemical composition of skeletal remains. The age at which they died, their sex, weight, and the associated intake of certain types of food may affect the amount of minerals found in the bones. For this reason, one of this paper's questions focuses on the different state of preservation between juvenile and adult individuals, which is based on the older belief that the bones of juvenile individuals contain more organic substances that are more susceptible to decomposition⁴³.

³⁸ ČURLÍK, Ján – ŠEFČÍK, Peter. Geochemický atlas Slovenskej republiky, časť V: Pôdy [online]. Bratislava. Štátny geologický ústav Dionýza Štúra, 2012. Available from: <http://apl.geology.sk/atlaspody>; 16.10.2025.

³⁹ DOBŠOVIČ, J. Pedologický prieskum pre strategické územie Valaliky k vyhotoveniu perspektívneho využitia poľnohospodárskeho pôdneho fondu na nepoľnohospodárske účely. Unpublished. Bratislava 2022.

⁴⁰ HIGH – MILNER – PANTER – PENKMAN, Apatite for destruction..., pp. 159–168.; KENDALL – ERIKSEN – KONTROPOULOS – COLLINS – TURNER-WALKER, Diagenesis of archaeological..., pp. 21–37; PROKEŠ, Posmrtné zmeny..., p. 9.

⁴¹ Identification numbers of the graves from which the material was sampled: 102, 107, 109, 111, 112, 113, 114, 117, 126, 145, 146, 156, 162, 163, 164, 166, 169, 171, 172, 175, 180, 181, 182, 186, 190, 192, 195, 201, 203, 204.

⁴² SŮRA, Roland. Protokol o skúške 20/2025. Unpublished. Bratislava 2025.

⁴³ GORDON – BUIKSTRA, Soil pH..., pp. 566–571.; GUY, Hervé – MASSET, Claude – BAUD, Charles-Albert. Infant taphonomy. In *International Journal of Osteoarchaeology*, 1997, 7, pp. 221–229.; JUNKINS, N. Emily – CARTER, O. David. Relationships between human remains, graves and the depositional en-

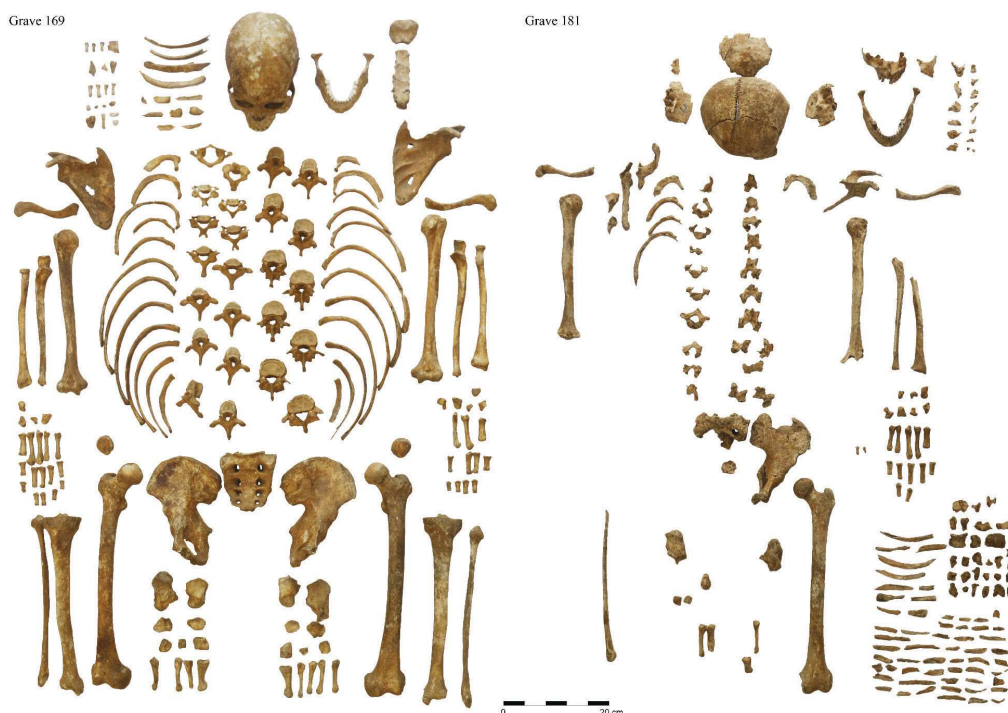


Fig. 2. Varying states of skeletal preservation, as exemplified by grave 169 – strong, complete bones, and grave 181 – extremely fragmented bones (TÁBIOVÁ, Odborný antropologický posudok. Druhá etapa hodnotenia: hroby 107-204...).

Another subject of analysis is the identification of soil pH, which also has a major impact on the state of preservation of the skeletal remains. It is generally assumed that during the decomposition of the body, the surrounding soil becomes acidic, although Haslam and Tibbet observed the opposite case, where the surrounding soil first became more alkaline⁴⁴. This condition is caused by the decomposition of soft tissues. The pH value of the soil will return to its original state over time. Experiments have shown that bones decompose faster in a more acidic environment ($\text{pH} < 7$), where the decomposition of inorganic compounds is accelerated. These values can lead to complete decomposition of the remains.

In a neutral and more alkaline environment, bones are better preserved. In alkaline soils, the organic components of bones degrade more quickly⁴⁵.

vironment. In Schotsmans, M. J. Eline et al. (eds.). *Taphonomy of Human Remains*. West Sussex 2017, pp. 145–154, 148.

⁴⁴ HASLAM, C. F. Tamsin– TIBBET, Mark. Soils of contrasting pH affect the decomposition of buried mammalian (*Ovis aries*) skeletal muscle tissue. In *Journal of Forensic Sciences*, 2009, vol. 54, no. 4, pp. 900–904, 903.

⁴⁵ GORDON – BUIKSTRA, Soil pH..., pp. 566–571.; HIGH – MILNER – PANTER – PENKMAN, Apatite for destruction..., pp. 159–168.; KENDALL – ERIKSEN – KONTOPOULOS – COLLINS – TURNER-WALKER, Diagenesis of archaeological..., pp. 21–37.; KIBBLEWHITE – TÓTH – HERMANN, Predicting the preservation..., pp. 249–263.; JUNKINS – CARTER, Relationships between..., pp. 147–148.; LÓPEZ-COSTAS, Olalla – LANTES-SUÁREZ, Óscar – CORTIZAS, M. Antonio. Chemical compositional changes in archaeological human bones due to diagenesis: Type of bone vs soil environment. In *Journal of Archaeological Science*, 2016, vol. 67, pp. 43–51.; MAYNE, H. Rosemary. *Geochemistry of the Soil and its Effect on Bone*. Unpublished thesis. Bournemouth 2013.; NIELSEN-MARSH – GER-

The preservation state of skeletons may also differ depending on whether the body was buried loosely in the ground or in a wooden coffin. Wood may contain wood-decay fungi, which passively reduce the pH of the environment through their activity on the wood, thereby accelerating the decomposition of bone material⁴⁶.

The depth of the grave significantly affects the rate of the skeletal remains decomposition. Individuals buried at greater depths are less exposed to surface conditions, whether related to environmental factors (flooding, plant root activity) or, in the case of finds located in areas subject to intensive agricultural activity, to the disturbance of the burial pit and the associated destruction of the bones⁴⁷.

Results and Discussion

An anthropological analysis of skeletal remains from the analysed graves shows that most of the skeletons were preserved in an extremely fragmented state, representing 96 individuals, followed by 77 individuals in a fragmented state, 76 individuals in a fragile state, and 20 individuals preserved in the form of strong complete bones (Figure 3; Table 1).

Tab. 1. Frequency table for state of preservation of skeletal remains at Valaliky burial ground.

Category	Count	Cumulative	Percent	Cumulative
Strong complete bones	20	20	7,43	7,43
Fragile bones	76	96	28,25	35,69
Fragmented bones	77	173	28,62	64,31
Extremely fragmented bones	96	269	35,69	100

One hundred and eighty adults over 20 years of age, 82 juveniles and five individuals between juvenile and adult age were identified at the burial site. In two situations, neither age nor sex could be estimated. Sex could be estimated for 185 adults and subjects between the age categories juvenis and adultus I. Of these, 56 persons were estimated to be male, 10 were estimated to be probably male, 63 were estimated to be female, 15 were estimated to be probably female, eight were interpreted as sex-indifferent and sex of other 33 individuals could not be determined (Table 2).

Statistical analysis of the relationship between age category (adults vs. juveniles) and skeletal preservation status was performed using the χ^2 test of independence. The results showed a statistically significant association between preservation status and age of individuals at the $\alpha = 0.05$ significance level ($p = 0.0086$). The effect size, expressed using

NAYE – TURNER-WALKER – HEDGES – PIKE – COLLINS, The chemical degradation..., pp. 439–454.; NIELSEN-MARSH – SMITH – JANS – NORD – KARS – COLLINS, Bone diagenesis..., pp. 1523–1531.; NORD, G. Anders – TRONNER, Kate – MATTSON, Einar – BORG, Ch. Gunnar – ULLÉN, Inga. Environmental Threats to Buried Archaeological Remains. In *A Journal of the Human Environment*, 2005, vol. 34, no. 3, pp. 256–262.; PROKEŠ, Posmrtné změny..., pp. 48.

⁴⁶ PÍŠTEKOVÁ, Tafonomie v archeologickém kontextu..., pp. 14–16.; PROKEŠ, Posmrtné změny..., p. 8.; TURNER-WALKER, Gordon. The chemical and microbial degradation of bones and teeth. In PINHASY, Ron – MAYS, Simon (eds.). *Advances in Human Palaeopathology*. West Sussex 2008, pp. 3–30.

⁴⁷ NORD – TRONNER – MATTSON – BORG – ULLÉN, Environmental Threats..., pp. 256–262.; TODISCO – MONCHOT. Bone weathering in a periglacial..., pp. 87–101.; TURNER-WALKER, The chemical and microbial..., pp. 3–30.



Fig. 3. Plan of the burial ground (LUŠTÍKOVÁ – GAŠPAR – VOJTEČEK – CHEBEN, „Strategické územie Valaliky“..., modified) with colour coding indicating preservation state of skeletal remains from the graves analysed to date: black – extremely fragmented bones, dark gray – fragmented bones, light gray – fragile bones, white – strong, complete bones.

Cramer's V, reached a value of 0.21, which corresponds to a weak to medium effect. Contingency table analysis indicates that juveniles had a higher than expected number of cases in the extremely fragmented skeletal category, while adults had a higher number in the fragile bone category. These results indicate that juvenile skeletal remains were generally in a worse state of preservation than adults (Table 3, Chart 1).

Tab. 2. Frequency table for sex estimation of skeletal remains at Valaliky burial ground.

Category	Juvenile/ adult	Percent	Adult	Percent	Count	Percent
Male	0	0	56	31,11	56	30,27
Male?	0	0	10	5,56	10	5,41
Female	1	20	62	34,44	63	34,05
Female?	1	20	14	7,78	15	8,11
Indifferent	1	20	7	3,89	8	4,32
Indeterminate	2	40	31	17,22	33	17,84
Count	5	100	180	100	185	100

Tab. 3. Statistical analysis of the relationship between the state of preservation of the osteological collection and the age of the individuals.

	Strong complete bones	Fragile bones	Fragmented bones	Extremely fragmented bones	Row
Adult	17	60	52	51	180
Juvenile	3	16	25	38	82
Totals	20	76	77	89	262

	Strong complete bones	Fragile bones	Fragmented bones	Extremely fragmented bones	Row
Adult	13,74	52,21	52,9	61,15	180
Juvenile	6,26	23,79	24,1	27,85	82
Totals	20	76	77	89	262

2-Way Summary Table: Observed minus Expected Frequencies					
	Strong complete bones	Fragile bones	Fragmented bones	Extremely fragmented bones	Row
Adult	3,26	7,79	-0,9	-10,15	0
Juvenile	-3,26	-7,79	0,9	10,15	0
Totals	0	0	0	0	0

Statistics: Age category x State of preservation					
		Chi-square	df	p	
Pearson Chi-square		11,61	df=3	p=,00886	
Cramér's V		0,21			

Tab. 4. Statistical analysis of the relationship between the state of preservation of the osteological collection and the sex of the adult individuals.

2-Way Summary Table: Observed Frequencies					
	Strong complete bones	Fragile bones	Fragmented bones	Extremely fragmented bones	Row
Adult	9	18	20	9	56
Juvenile	7	28	24	4	63
Totals	16	46	44	13	119

2-Way Summary Table: Expected Frequencies					
	Strong complete bones	Fragile bones	Fragmented bones	Extremely fragmented bones	Row
Adult	7,53	21,65	20,71	6,12	56
Juvenile	8,47	24,35	23,29	6,88	63
Totals	16	46	44	13	119

2-Way Summary Table: Observed minus Expected Frequencies					
	Strong complete bones	Fragile bones	Fragmented bones	Extremely fragmented bones	Row
Adult	1,47	-3,65	-0,71	2,88	0
Juvenile	-1,47	3,65	0,71	-2,88	0
Totals	0	0	0	0	0

Statistics: Age category x State of preservation					
		Chi-square	df	p	
Pearson Chi-square		4,31	df=3	p=,22951	
Cramér's V		0,19			

Chart 1. Interaction plot between age estimation and state of preservation.

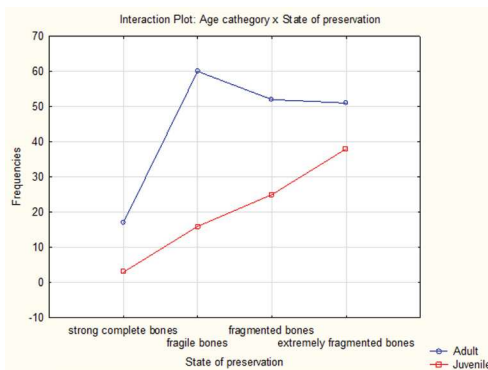
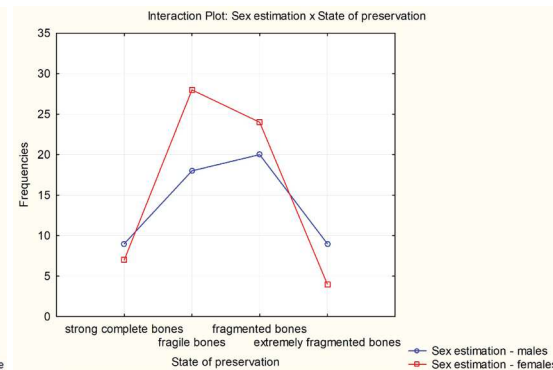


Chart 2. Interaction plot between sex estimation and state of preservation.



The relationship between the state of preservation of skeletal remains in adult males and females was not demonstrated based on the χ^2 test of independence at the significance level $\alpha = 0.05$ ($p = 0.22951$; Table 4, Chart 2).

The low representation of individuals in the extremely fragmented bones category may also be related to the fact that sex estimation is significantly limited for skeletal remains in this state of preservation. Future identification of remains belonging to sex-undetermined individuals could contribute to more accurate and robust statistical analyses in the future.

Another potential factor influencing the variability in skeletal preservation was examined in relation to burial practices, specifically the manner in which the bodies were deposited in the ground. Evidence of wooden remains, which could indicate the presence of a coffin, or a dark layer beneath the skeleton that might suggest a specific burial preparation, was observed in only 25 graves displaying varying degrees of skeletal preservation. According to the results of the χ^2 test, no statistically significant association was identified between the state of skeletal preservation and the presence of special grave treatment. This suggests that burial modifications did not have a measurable effect on the preservation of skeletal remains at this cemetery (Table 5, Chart 3).

An important parameter in the context of burial rites could be the depth of the burial pit, which ranged from 2 cm to 83 cm, with an average of 26 cm⁴⁸. These are artificial values, as it is difficult to estimate the elevation of the original ground level in the past. The examined area had been subject to several years of intensive agricultural activity. Before applying statistical tests, it was necessary to verify the distribution of the data using a normality test. Since the resulting p-value reached 0.00, the null hypothesis of a normal distribution of the data was rejected, despite the fact that visual inspection of the graph

⁴⁸ The shallow depth of the grave pits is related to the complications in their identification in the field. In this case, it is likely that the grave pits were only recognized after the discovery of osteological remains.

indicated an approximate concentration of values around the normal curve. For this reason, it was necessary to use non-parametric methods, namely Spearman's correlation coefficient, for further statistical evaluation (Table 6, 7, Chart 4).

Tab. 5. Statistical analysis of the relationship between the state of preservation of the osteological collection and the possible special condition of the grave pit: With – grave with special conditions such as the presence of wood or a darker layer of soil under the skeleton; Without – grave without special conditions.

2-Way Summary Table: Observed Frequencies			
	Without	With	Row
Strong complete bones	19	1	20
Fragile bones	67	9	76
Fragmented bones	69	8	77
Extremely fragmented bones	89	7	96
Totals	244	25	269

Statistics: State of preservation) x Special grave modification			
	Chi-square	df	p
Pearson Chi-square	1,59	df=3	p=,66188
Cramér's V	0,077		

Chart 3. Interaction plot between state of preservation and probable special grave modification: With - grave with special modification such as the presence of wood or a darker layer of soil under the skeleton; Without – grave without special conditions

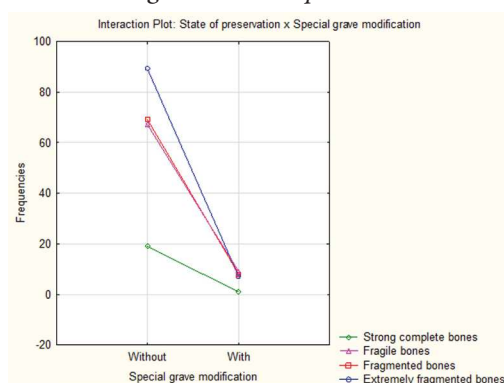
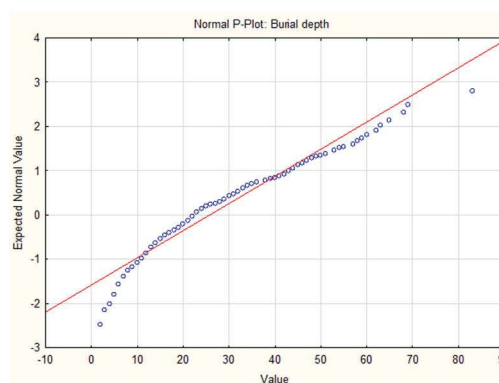


Chart 4. Normal P-plot for the burial depth variable.



Based on the results of the Spearman correlation coefficient ($p = 0.1$), no statistically significant correlation was demonstrated between the depth of the graves and the state of preservation of skeletal remains. From this it can be concluded that the depth of the graves was not a significant factor influencing the state of preservation of the osteological remains at the investigated burial site (Table 8).

Tab. 6. Descriptive statistics for burial depth data.

Variable	Valid N	Mean	Minimum	Maximum	Std.Dev.
Burial depth	257	25,77432	2	83	15,70665

Tab. 7. Tests of normality for data about the grave depth.

Variable	N	max D	K-S	Lilliefors	W	p
Burial depth	257	0,113065	p < ,01	p < ,01	0,941102	0

Tab. 8. Spearman rank order correlations for state of preservation and burial depth.

	Valid	Spearman	t(N-2)	p-value
State of preservation x Burial depth	257	-0,102254	-1,64146	0,101934

Further analysis focused on examining the correlation between the state of skeletal preservation and soil pH in the graves in question (Figure 4). The soil pH was found to range from 6.67 to 8.58, with an average value of 7.842. This is a range between a slightly acidic to slightly alkaline environment, with an average in neutral to slightly alkaline values (Table 9).

Tab. 9. Descriptive statistics for pH variable.

Variable	Valid N	Mean	Minimum	Maximum	Std.Dev.
pH	30	7,842	6,67	8,58	0,649612

The evaluation of the results required verification of the normality of the data distribution. The normality test showed that the null hypothesis of a normal distribution of pH values was rejected at the significance level $\alpha = 0.05$ ($p = 0.000065$). Based on this finding, non-parametric tests were applied for further statistical evaluation (Table 10, Chart 5).

Tab. 10. Tests of normality for pH variable.

Variable	N	max D	K-S	Lilliefors	W	p
pH	30	0,276788	p < ,05	p < ,01	0,799951	0,000065

The results of the Spearman correlation coefficient indicated a trend that the state of preservation of osteological remains improves with increasing pH value. However, this relationship was not statistically confirmed at the significance level $\alpha = 0.05$ ($p = 0.06$; Table 11).

Tab. 11. Spearman rank order correlations between state of preservation and pH.

	Valid	Spearman	t(N-2)	p-value
State of preservation x pH	30	-0,346263	-1,95307	0,060871

The relationship between the state of preservation of skeletal remains and pH values was not proved using the Spearman correlation test in either men ($p = 0.28$) or women ($p = 0.16$) at the significance level $\alpha = 0.05$ (Table 12).

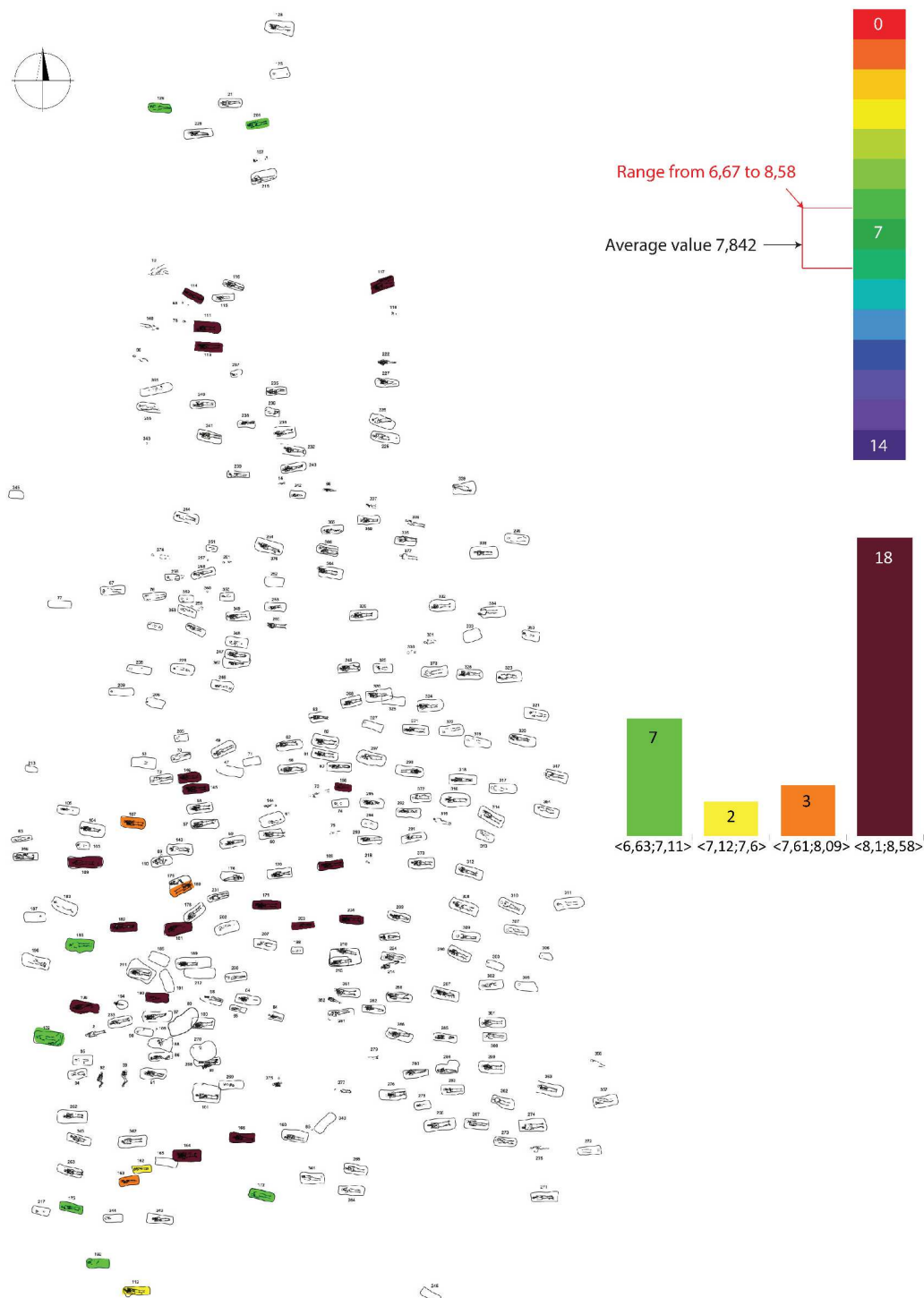


Fig. 4. Plan of the burial ground (LUŠŤÍKOVÁ – GAŠPAR – VOJTEČEK – CHEBEN, „Strategické územie Valaliky“..., modified) with colour-coded graves from which soil samples were taken for pH analysis. The data on the pH scale show the results of the analyses. The graph shows the interval distribution of pH values (the colours of the graph and map correspond): burgundy 8.58-8.1, orange 8.09-7.61, yellow 7.6-7.12, green 7.11-6.63.

Tab. 12. Spearman rank order correlations between pH and state of preservation for males and females.

	Valid	Spearman	t(N-2)	p-value
pH x State of preservation – Males	12	-0,340165	-1,14391	0,279304

	Valid	Spearman	t(N-2)	p-value
pH x State of preservation – Females	10	-0,480305	-1,54886	0,160008

When analyzing the relationship between the age of individuals and pH values, a statistically significant dependence was demonstrated for adult individuals ($p = 0.0099$). The results indicate that a more acidic soil environment (lower pH values) contributed to a worse state of preservation of skeletal remains, with a moderately strong negative correlation (Spearman $r = -0.5158$). No clear trend was observed for juvenile individuals (Table 13). The application of the Mann–Whitney U test also demonstrated that there was no statistically significant difference between the pH values of the soil in which the remains of adults and juvenile individuals were deposited ($p = 0.96$; $Z = 0.05$; Table 14), indicating that both groups were exposed to approximately the same soil conditions. These results in the state of preservation found may be due to the low number of juvenile individuals included in the analysis ($N = 6$) or to the biological properties of children’s bones, which, due to their structure, undergo decomposition processes more quickly. However, the graphical representation (Chart 6) suggests an opposite trend, according to which juvenile remains might be less well preserved in more alkaline soils (with higher pH). However, further observations and analyses are required to verify this hypothesis.

Tab. 13. Spearman rank order correlations between pH and state of preservation for adults and juveniles.

	Valid	Spearman	t(N-2)	p-value
pH x State of preservation - Adults	24	-0,515844	-2,82429	0,009875

	Valid	Spearman	t(N-2)	p-value
pH x State of preservation - Juveniles	6	0,717137	2,057983	0,108701

Tab. 14. Mann-Whitney U test by variable pH between adults and juveniles.

	Rank Sum	Rank Sum	U	Z	p-value	Z	p-value	Valid N	Valid N	2*1sided
pH	373,5	91,5	70,5	0,05	0,96	0,05	0,96	24	6	0,94

Natural conditions, especially the geological settings and soil properties, could also have influenced the preservation state of the skeletons. According to the geological map⁴⁹, the examined burial ground lies on fluvial sediments, which are classified in terms of age as

⁴⁹ KALIČIAK – BAŇACKÝ – JANOČKO – KAROLI – PETRO – SPIŠÁK – VOZÁR – ŽEC, Geologická mapa Slanských vrchov...

Chart 5. Normal P-plot for the burial pH variable.

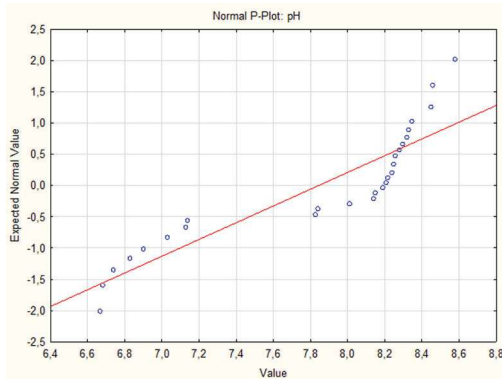
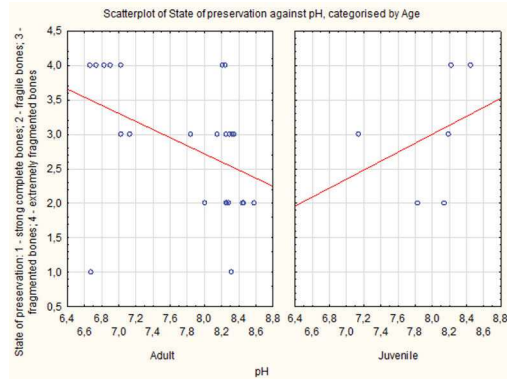


Chart 6. Scatterplot of state of preservations against pH, categorised by age.



older Riss period, forming the sedimentary fill of the 2nd middle terrace. This stretches from the southern edge of Košice to the village of Seňa. The surface of the terrace is approximately 12 m above the present-day floodplain. With a thickness of fluvial accumulation of approximately 2 – 3 m, the base of the terrace reaches a relative height of 7 – 10 m. The gravels are subrounded and rounded, with an average size of 3 – 4 cm, max. 12 cm, predominantly massive-bedded and occasionally positively graded (normal graded bedding). They are composed of quartz, quartzite, metamorphic rocks, occasionally carbonates, andesites, conglomerates, and sandstones. The matrix is fine-grained sand with very poor sorting. Towards the east, the terrace in question is limited by a low terrace, classified to the Würm Age, on which there are also aeolian sands with short transport, forming slight longitudinal elevations (dunes)⁵⁰.

Field survey and documentation of excavated shafts at the burial site confirmed fluvial accumulation of the Hornád River in the form of gravelly sand, locally also with layers of clay. An accumulation of (?aeolic) sand without visible stratification was identified on these sediments in the form of a longitudinal ridge, relatively prominent in the terrain, with a maximum thickness of approximately 1.5 m. The thickness of the sand decreased towards the edges of the ridge. The nature of these sediments, as well as their morphological position and shape generated from detailed DTM 5.0 (Figure 5), indicate that they are probably sands of aeolian origin, which were blown from the terrace accumulation, thus forming an elevated sand dune. The presumed dune is 60 – 70 m wide and 480 m long (Figure 5: A). The presence of dunes of aeolian sands on a nearby low terrace⁵¹ may also imply the correctness of the assumption of aeolian genesis of the accumulation. The results show that the entire burial ground was located on a sand dune (Figure 5). Therefore, the location of individual graves in the terrain probably did not affect the varying degrees of preservation of the bones in them.

Another possible determinant of the different state of skeletal preservation could be the different soil types within individual graves. However, analysis shows that Cambisol is

⁵⁰ JANOČKO, Juraj – BAŇACKÝ, Vladimír. Kvartér. In KALIČIAK, Michal et al. (eds.). Vysvetlivky ku geologickej mape Slanských vrchov a Košickej kotliny – južná časť 1:50 000. Bratislava 1996, pp. 95–116.

⁵¹ JANOČKO – BAŇACKÝ, Kvartér..., pp. 95–116.

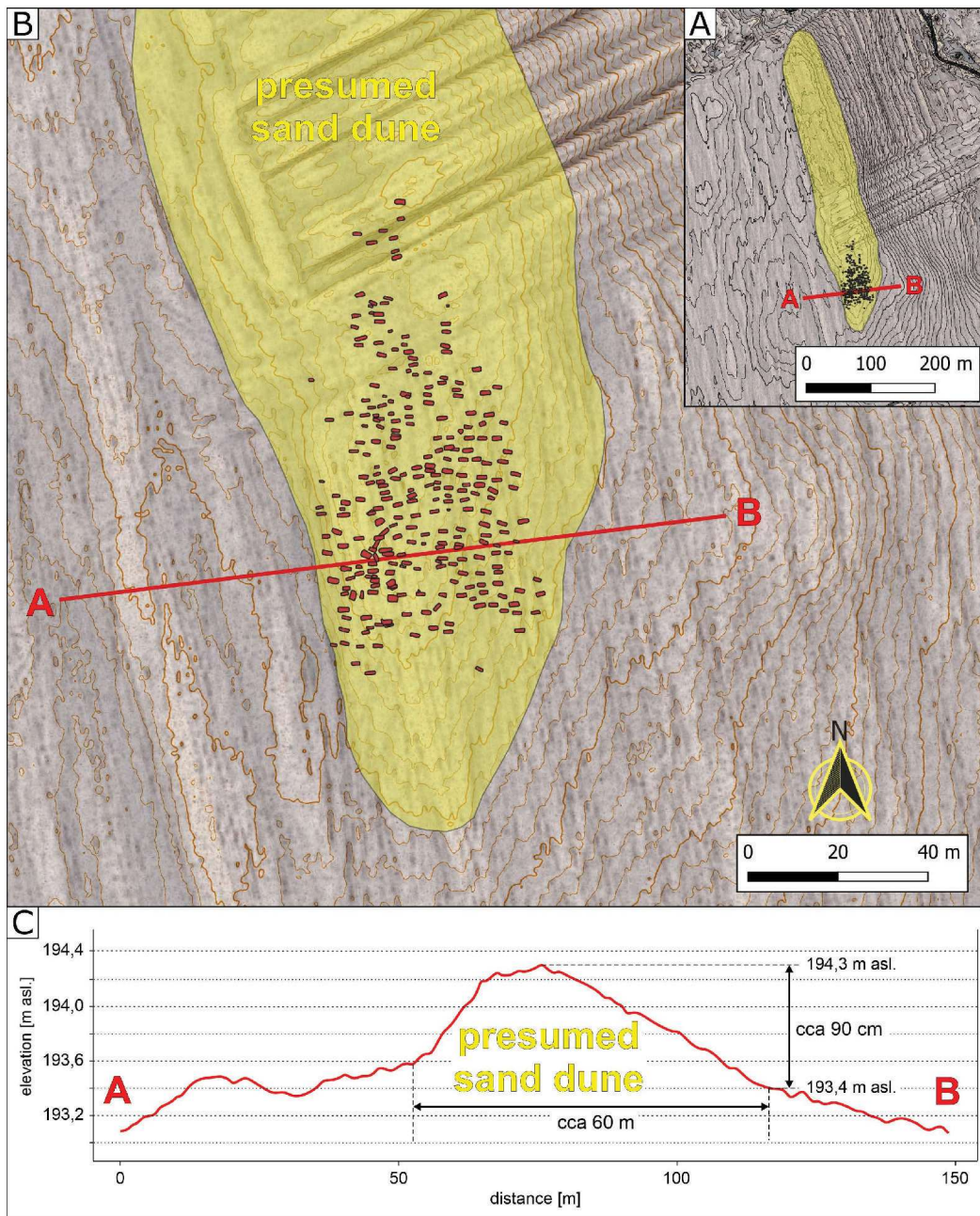


Fig. 5. A – Position of the burial ground within the entire extent of the presumed dune. The contour interval is 20 cm. B – Detail of the burial ground with the profile line (marked A-B) of the cross-section in section C. The base map is a modified derivative of the DTM 5.0 digital terrain model (ÚGKK SR). The contour interval is 10 cm. C – Cross-section of the presumed aeolian dune with its approximate parameters generated from DTM 5.0 (height, width) at the burial site.

present throughout the entire burial ground and its immediate surroundings⁵². According

⁵² ŠÁLY – ŠURINA, *Pôdy...*, p. 107.; DŽATKO – SOBOCKÁ – GRANEC – BEZÁK, *Príručka pre používanie máp...*, pp. 101.; DOBŠOVIČ, *Pedologický prieskum...*

to more accurate data from soil sampling sites (red dots and arrows⁵³), the soil in the immediate vicinity of the burial ground is Regosol, i.e., soil developed on sand (Figure 6).

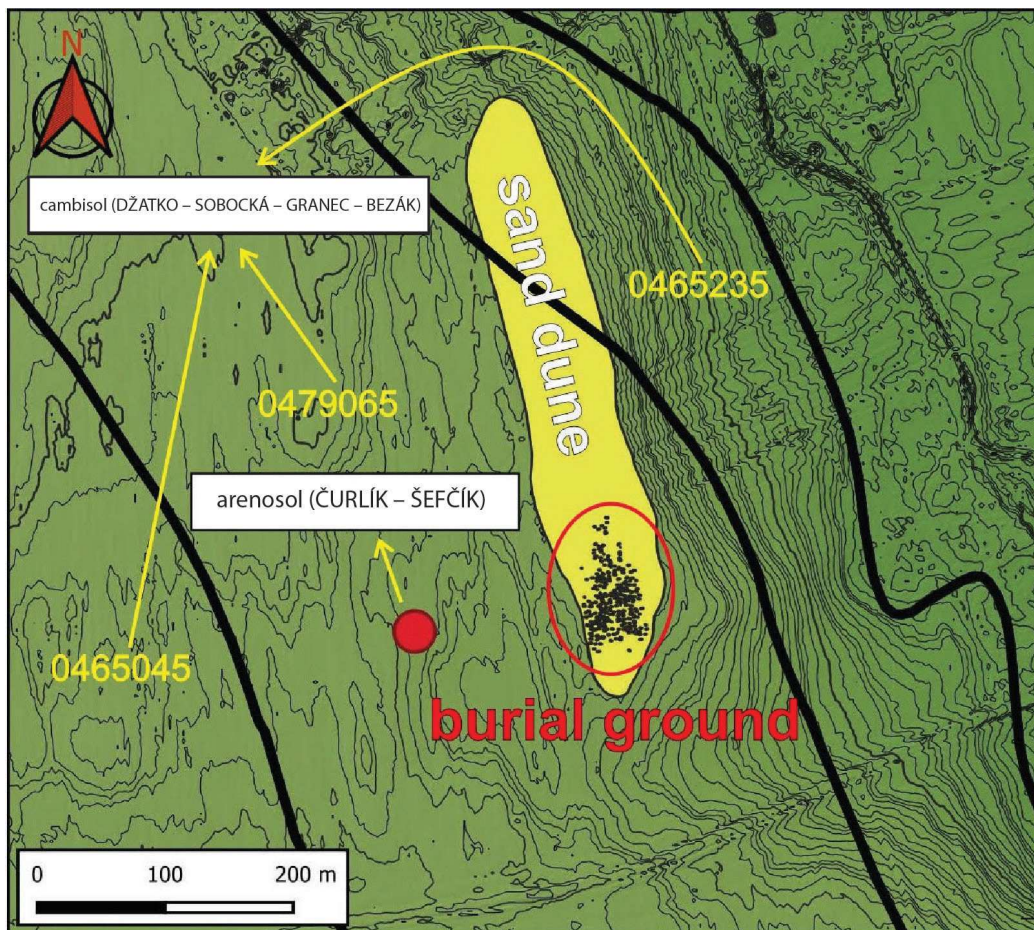


Fig. 6. Soil conditions in the vicinity of the studied locality of the burial ground. The base map is the DMR 5.0 digital terrain model (ÚGKK SR) with contour lines (height interval 20 cm).

In addition to the aforementioned analyses, the dynamic properties of the surrounding environment also play an important role. Foremost, it is essential to mention the properties of water. The hydrodynamics, groundwater movement, and fluctuations in water level negatively affect the condition of the remains and accelerate its degradation. Bones tend to absorb water, which causes them to degrade both externally and internally, especially when dry and wet periods alternate continuously. Water movement causes tissue abrasion, and water with varying mineral



Fig. 7. Preserved bone fragment (probably diaphysis of ulna or radius) bearing traces or residues of a metal object from grave 67 (TÁBIOVÁ, Odborný antropologický posudok. Prvá etapa hodnotenia: hroby 2-106...).



⁵³ ČURLÍK – ŠEFČÍK, Geochemický atlas Slovenskej republiky..., Figure 3.

content can also alter the pH of the surrounding environment, accelerating decomposition. Moist environment also attracts plant root systems, which can cause roots to grow more quickly around bones. Roots extract material from bones and create characteristic patterns on their surfaces. On the other hand, non-fluctuating water environments appear to be more favourable to better preservation⁵⁴. The rate of bone decomposition also depends on the mineral content of the soil. Increased amount of calcium and phosphate cations can have a very positive effect on the preservation of skeletal remains, while their absence accelerates decomposition. The decomposition rate also depends on the porosity of the bones themselves⁵⁵. Identifying the soil type is also important. In this case, the main factors are soil pH value, dynamics of water level, and soil permeability⁵⁶. The preservation of skeletal remains is also further compromised by the presence of various organisms, which either decompose the bones with their excretions, or, in the case of macroorganisms, gnaw on the bones⁵⁷.

Another possible element that could influence the degree of skeletal preservation is grave goods. On the skeletal remains from the examined burial site, several traces of metal objects have been recorded, consistently occurring on well-preserved bones (Figure 7). For now, this topic remains at the level of hypothesis.

Conclusion

The state of preservation of skeletal remains was related to the age of the individuals, with a weak to moderate correlation; child remains were generally worse preserved than adult remains. Although the relationship between pH values and state of preservation was not statistically significant ($p = 0.06$), a trend was observed indicating worse preservation of bones in a more acidic environment. The statistically significant relationship between these variables was confirmed in a separate analysis of the adult category. The results indicate that an environment with a lower pH has a more destructive effect on skeletal remains and accelerates its decomposition. On the contrary, variables such as the sex of the individual, special grave treatment, depth of the grave pit or the relationship between sex and pH values did not show a statistically significant correlation with the state of preservation. Given the fact that the entire burial site is situated on a sand dune, it is likely that the placement of the graves itself did not have a significant impact on the state of preservation of the skeletal remains.

In general, several factors simultaneously affect the preservation of the skeletal remains, and it is not possible to clearly separate them from each other. Therefore, this study focused on the basic methods that could be applied given the nature of the archaeological research.

⁵⁴ HIGH – MILNER – PANTER – PENKMAN, Apatite for destruction..., pp. 159–168.; KENDALL – ERIKSEN – KONTROPOULOS – COLLINS – TURNER-WALKER, Diagenesis of archaeological..., pp. 21–37.; KIBBLEWHITE – TÓTH – HERMANN, Predicting the preservation..., pp. 249–263.; PROKEŠ, Posmrtné změny..., pp. 48.; TURNER-WALKER, The chemical and microbial..., pp. 3–30.

⁵⁵ KENDALL – ERIKSEN – KONTROPOULOS – COLLINS – TURNER-WALKER, Diagenesis of archaeological..., pp. 21–37.; NIELSEN-MARSH – GERNAYE – TURNER-WALKER – HEDGES – PIKE – COLLINS, The chemical degradation..., pp. 439–454.

⁵⁶ BROTHWELL, R. Don. *Digging up Bones*. Ithaca, NY 1981, pp. 219.

⁵⁷ PROKEŠ, Posmrtné změny..., pp. 48.

A methodologically well-designed research can help predict the appropriate archaeological methods to be applied during archaeological research, and thus improve the preservation of remains⁵⁸.

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⁵⁸ see HIGH – MILNER – PANTER – PENKMAN, Apatite for destruction..., pp. 159–168.

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