Title:
Establishing Deep Time: Multi-Method Dating of Archaeological and Speleological Features in the Bosnian Valley of the Pyramids

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Rationale for Submission to EarthArXiv:
EarthArXiv serves as a preprint repository for research across the Earth sciences, including geology, geochronology, soil science, and archaeological science. This manuscript fits EarthArXiv's scope as it applies rigorous Earth science methodologies—including radiocarbon dating, uranium-thorium dating, and pedogenetic analysis—to archaeological and speleological contexts in Southeastern Europe. The paper contributes to ongoing debates in geoarchaeology and deep-time human activity by presenting verifiable chronological data from internationally recognized laboratories. The interdisciplinary and open-science nature of the work makes EarthArXiv an ideal platform to share these findings with the global geoscience and archaeological research communities prior to formal peer review.

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Abstract

This study presents an integrated chronological framework for the Bosnian Valley of the Pyramids using multiple scientific dating techniques. Radiocarbon dating, uranium-thorium analysis, and soil pedogenesis studies were conducted on archaeological and speleological features including the Bosnian Pyramid of the Sun, the Pyramid of the Moon, and the Ravne tunnel networks. Results suggest construction and usage of these structures as early as 33,800 years BP, with corroborating stratigraphic and geological indicators. The presence of architectural elements beneath undisturbed soil layers and stalagmites over tunnel floors reinforces their antiquity. These findings contribute to the growing evidence of organized human activity in Southeastern Europe during the Late Pleistocene. The application of cross-disciplinary dating methods demonstrates the value of integrated geoarchaeological approaches in establishing deep-time chronologies at complex heritage sites.

Keywords

Radiocarbon Dating, Bosnian Pyramids, Ravne Tunnel Complex, Speleothem Chronology, Paleoarchaeology, Multi-method Geochronology

1. Introduction

The Bosnian Valley of the Pyramids, located near the town of Visoko in central Bosnia-Herzegovina, has emerged over the past two decades as one of the most debated archaeological landscapes in Southeastern Europe. Since its identification as a site of interest in the early 2000s,

the area has undergone continuous excavation and multidisciplinary study led by the Archaeological Park: Bosnian Pyramid of the Sun Foundation. The valley includes prominent geomorphological features such as the Bosnian Pyramid of the Sun, the Pyramid of the Moon, the Pyramid of the Dragon, and an extensive network of subterranean passages known as the Ravne Tunnels.

Despite initial skepticism regarding the anthropogenic nature of these formations, accumulating stratigraphic, architectural, and geophysical evidence has warranted closer scientific investigation. Notably, numerous megalithic terraces, aligned dry-stone walls, and artificially shaped concrete-like blocks have been unearthed at several depths and across multiple pyramid structures. In parallel, the Ravne tunnel systems have yielded dry-stone reinforcements, complex sediment layers, and speleothem formations which provide invaluable temporal markers.

To establish a scientifically grounded chronology for the valley's development, the current research integrates multiple dating techniques. Radiocarbon (C-14) dating, Uranium-Thorium (U-Th) series analysis, and pedogenetic soil assessment have been applied to organic remains, speleothems, and stratified construction materials. These analyses aim to identify both minimum and possible construction dates and offer a framework for interpreting phases of human activity in the region.

This paper presents the results of these multi-method dating efforts and evaluates their implications within the broader context of Balkan prehistory and deep-time archaeology. Emphasis is placed on methodological transparency, cross-validation of results, and careful consideration of post-depositional processes that may affect dating accuracy. By doing so, the study contributes to a more nuanced understanding of long-term human-environment interaction in one of Europe's least-explored prehistoric landscapes.

2. Materials and Methods

This study applies a multi-method chronological approach to key sites within the Bosnian Valley of the Pyramids, including the Bosnian Pyramids of the Sun and Moon, as well as the Ravne and Ravne 3 tunnel systems. Analytical material included organic remains (charcoal, wood, sediment-bound carbon), carbonate formations (stalagmites, calcite crusts), soil layers, and structural elements recovered from systematic excavation campaigns spanning 2006 to 2025.

2.1 Excavation Strategy and Site Selection

Excavation was conducted under the supervision of the *Archaeological Park: Bosnian Pyramid of the Sun Foundation*, with formal permits issued by the Cantonal Ministry of Culture (Zenica-Doboj Canton). A total of **20 trenches** were opened on the Bosnian Pyramid of the Sun and **64 trenches** on the Bosnian Pyramid of the Moon. Over **2.6 kilometers of tunnels** were cleared in the Ravne and Ravne 3 underground complexes. Stratigraphic excavation, trench documentation, and material sampling were conducted according to standard archaeological protocols.

2.2 Radiocarbon (C-14) Dating

Organic material—including wood fragments, charcoal, and carbon-containing sediments—was submitted for radiocarbon analysis to the following laboratories:

- **Institute of Environmental Geochemistry**, National Academy of Sciences, Kyiv (Ukraine)
- **Beta Analytic Radiocarbon Dating Laboratory**, Miami (USA)
- **TÜBİTAK Marmara Research Center AMS Laboratory**, Gebze (Turkey)
- **Laboratory for Isotope Research**, Silesian University of Technology, Gliwice (Poland)
- **Angström Laboratory**, Uppsala University (Sweden)
- **Leibniz Laboratory for Radiometric Dating and Stable Isotope Research**, Christian-Albrechts University, Kiel (Germany)

Samples underwent standard pre-treatment protocols including Acid-Base-Acid (ABA) processing or acid dissolution (for carbonates). AMS (Accelerator Mass Spectrometry) and liquid scintillation counting methods were used. Radiocarbon dates were calibrated using the **IntCal13** or **IntCal20** Northern Hemisphere calibration curves.

2.3 Uranium-Thorium (U-Th) Series Dating

U-Th dating was applied to stalagmites and calcite crusts found in undisturbed sections of the Ravne 3 tunnel. Laboratory analysis was conducted as follows:

- **Chemical separation** of uranium and thorium was performed using **TRU-resin chromatographic extraction** at the **Institute of Geological Sciences**, Polish Academy of Sciences (Warsaw).
- **Isotopic measurements** were completed at the **Institute of Geology**, Czech Academy of Sciences (Prague), using a double-focusing sector-field **ICP-MS (Element 2, Thermo Finnigan)**.

All results were corrected for blanks and isotopic fractionation using internal laboratory standards.

2.4 Soil Pedogenesis and Relative Dating

Soil samples taken from sediment layers overlying structural elements (e.g., concrete blocks) were examined by the **Federal Institute for Agropedology** (Sarajevo). Chronological estimates were based on depth, humus concentration, and clay mineral content. These data provided a relative terminus ante quem for underlying features.

2.5 Documentation and Visualization

Each sample context was documented with scaled photography, stratigraphic sketches, and GIS-based mapping. 3D terrain modeling and remote sensing data (including LiDAR and satellite-

based elevation models) were integrated into the geomorphological analysis, particularly around the Bosnian Pyramid of the Moon and related alignments

3. Results

3.1 Bosnian Pyramid of the Sun

Excavations conducted across 20 archaeological trenches on the Bosnian Pyramid of the Sun uncovered structural features consistent with artificial construction. Large, regularly shaped concrete-like blocks were found approximately 1 meter beneath the surface layer of soil and vegetation (Figure 2). These blocks were arranged in rows and exhibited uniform orientation and smooth surfaces, particularly in Trench 4C and at the uncovered northeastern corner (Figure 3).

Radiocarbon dating of organic material found between these concrete layers yielded significant chronological results. A sample submitted to the Kyiv radiocarbon laboratory (IHME-3734) produced an uncalibrated age of **29,200 ± 400 BP**, which calibrates to approximately **33,800 years BP** using the IntCal calibration curve (Figure 6). An earlier sample from Trench 20 dated to **24,800 ± 200 BP** supports this Late Pleistocene construction estimate (Figure 5). These findings are consistent with earlier soil analyses performed by the Federal Institute for Agropedology in Sarajevo, which dated the overlying pedogenic soil to between **12,000 and 15,000 years BP**, confirming that the structure beneath must be older (Figure 1).

Complementary interpretations by Dr. Paul LaViolette and others have affirmed this chronology, projecting a calibrated construction window of approximately **33,800 BP** (Figure 6).

3.2 Bosnian Pyramid of the Moon

The Bosnian Pyramid of the Moon was investigated through 64 archaeological trenches, which uncovered extensive sandstone terraces arranged in a stepped or cascading pattern from base to summit (Figure 8). Terraces were arranged along a north–south axis and often separated by thin layers of clay, possibly used for acoustic or thermal insulation (Figure 4).

In 2013, radiocarbon analysis was performed on carbon-rich material embedded within these terraces. Laboratory results from Kyiv and Uppsala yielded uncalibrated ages of **10,350 ± 50 BP** and **6,450 ± 30 BP**, respectively (Figure 9). These dates, though significantly younger than those from the Pyramid of the Sun, still suggest the site's prehistoric occupation.

Astronomical alignments associated with the Pyramid of the Moon further contextualize its importance. Observations indicate that during the summer solstice, the shadow of the Pyramid of the Sun completely envelopes the Pyramid of the Moon just before sunset, touching its summit (Figure 7). Additional astronomical shadow phenomena are observed during the equinoxes and winter solstice (Figures 20–22).

3.3 Ravne and Ravne 3 Tunnel Complexes

Systematic clearing of over **2.6 kilometers** of the Ravne tunnel network revealed more than **50 dry-stone walls**, five side chambers, and several large ceramic megaliths (Figure 10). Radiocarbon dating of organic materials extracted from tunnel fill produced diverse results. Charcoal from near a dry-stone wall in Ravne 3 was dated by TÜBİTAK AMS Laboratory to **1677 ± 23 BP**, corresponding to a calibrated range of **261–423 CE**, indicating post-construction visitation during Late Antiquity (Figure 17).

Earlier radiocarbon results from the Ravne tunnels provided more ancient dates:

- A wooden artifact embedded in conglomerate dated to **34,000 ± 1,500 BP** by Silesian University (Gliwice)
- A second sample from the same object dated to **30,600 ± 525 BP** by Leibniz Laboratory, Kiel (Figure 12)

These dates suggest a much earlier formation or reuse of the tunnels than previously considered.

Stalagmites within Ravne 3 provided additional chronological insight. Radiocarbon dating of the S001 sample produced a wide range of ages, including a layer dated to **26,200 ± 250 BP** (Figure 15). U-Th dating of nearby stalagmites (US001 and S008) produced ages of **19,000 ± 1,000 BP** and **15,000 ± 1,000 BP**, respectively, further corroborating the deep antiquity of tunnel formation (Figure 16).

Calcite crystal formations on the ceilings of the Ravne water section were also dated. A sample analyzed by Beta Analytic returned a calibrated age of approximately **7,430 years BP**, indicating water infiltration and mineral deposition well before recorded history (Figure 18).

3.4 Summary of Dating Results

A synthesized chronology, presented in flowchart form (Diagram: *Step-by-Step Dating of the Bosnian Pyramid of the Sun*), integrates these multi-method dating results. The combined use of radiocarbon, U-Th, and soil profile analysis establishes a **multi-phase chronology**:

- Construction of the Bosnian Pyramid of the Sun: ~33,800 BP
- Primary activity in Ravne tunnel: ≥30,000 BP
- Use of the Pyramid of the Moon: 10,000–6,500 BP
- Post-construction human activity: ~4th century CE

4. Discussion

The results of this study contribute significantly to the growing body of interdisciplinary research on the Bosnian Valley of the Pyramids by establishing a layered and testable chronological framework. Through the combined application of radiocarbon and uranium-thorium dating, supported by soil profile analysis and stratigraphic observations, a compelling temporal sequence emerges that challenges conventional interpretations of the site's age and complexity.

4.1 Chronological Implications for Construction and Use

The radiocarbon dates obtained from organic material embedded between concrete-like blocks on the Bosnian Pyramid of the Sun—especially the calibrated age of ~33,800 BP—suggest a construction phase that predates the Neolithic by tens of thousands of years. This places the pyramid well into the Late Upper Paleolithic, an era for which there is limited documentation of monumental construction on a global scale. The soil development analysis conducted by the Federal Institute for Agropedology supports this conclusion, dating the overlying soil to a minimum of 12,000–15,000 years old, thereby establishing a relative terminus ante quem for the pyramid's surface features.

The Pyramid of the Moon, while younger in construction, reveals continuous use or modification across millennia, with radiocarbon dates clustering around 10,000–6,500 BP. The consistency of its terrace formations and their integration into astronomical alignments further support the interpretation of intentional design. Observations of solstitial and equinoctial shadow interactions between the Sun and Moon pyramids imply a high level of planning and astronomical knowledge.

4.2 Ravne Tunnel System: Age, Function, and Reuse

The extensive network of Ravne and Ravne 3 tunnels presents a complex palimpsest of activity. The U-Th and radiocarbon dating of stalagmites, calcite deposits, and embedded wood indicate that many sections were open or accessible as early as 30,000–34,000 years BP. These results are bolstered by the presence of megalithic blocks beneath stratified conglomerate layers, suggesting tunnel formation prior to sediment infill and natural sealing.

Notably, more recent human interaction with the tunnels is confirmed by charcoal samples dated to the 4th century CE, likely reflecting reuse or ritual visitation rather than original construction. This pattern of initial Paleolithic construction followed by millennia of silence and eventual rediscovery is consistent with other ancient megalithic sites globally.

4.3 Methodological Reliability and Interdisciplinary Integrity

While early debates surrounding the Bosnian Pyramids focused heavily on their classification as natural or artificial, this study emphasizes the value of verifiable scientific methods to bypass that dichotomy. The chronological data presented herein are independently verifiable, laboratory-validated, and sourced from internationally accredited institutions.

The potential presence of "dead carbon" in speleothems and sediment-bound samples was accounted for through methodological triangulation—combining U-Th and C-14 dating with geochemical context to assess contamination risks. Calibration curves (IntCal13 and IntCal20) were consistently applied, and sample integrity was maintained through careful stratigraphic documentation and international submission protocols.

4.4 Context within Southeastern European Prehistory

The findings of this study suggest the Bosnian Valley of the Pyramids may represent one of the earliest examples of megalithic activity in Southeastern Europe, potentially predating known Mesolithic and Neolithic cultures in the region. While this interpretation remains provisional, pending further excavation and interdisciplinary review, the currently available evidence necessitates the reconsideration of cultural capacities in the Late Pleistocene Balkans.

5. Future Research Directions

The results presented in this study underscore the need for continued, multidisciplinary investigation of the Bosnian Valley of the Pyramids. The unexpectedly early radiometric dates, particularly those related to the Bosnian Pyramid of the Sun and the Ravne tunnel system, invite further scrutiny—not only to refine current chronologies but also to explore the broader cultural and environmental implications of the findings.

5.1 Expanded Radiometric Sampling

Future work should prioritize broader radiocarbon and U-Th sampling across stratified contexts and a wider variety of materials. This includes:

- Additional dating of stalagmites and calcite crusts in the less-disturbed sectors of Ravne 3;
- Targeted radiocarbon analysis of organic residues found beneath megalithic terraces on the Pyramid of the Moon;
- Testing of sedimentary carbonates within sealed segments of the Ravne tunnels, especially where construction-like dry walls intersect flowstone deposits.

Ensuring redundant testing across multiple laboratories will further strengthen chronological confidence and mitigate concerns over localized contamination.

5.2 Geoarchaeological Correlation

Improved correlation between radiometric dates and geomorphological processes—such as sediment transport, percolation pathways, and pedogenic changes—will help differentiate between construction-related events and natural depositional sequences. Detailed soil micromorphology, isotope geochemistry, and mineral composition studies could offer further insights into anthropogenic versus natural layering.

5.3 Non-Invasive Subsurface Imaging

Geophysical techniques such as ground-penetrating radar (GPR), electrical resistivity tomography (ERT), and muon tomography should be deployed more extensively to detect potential internal structures within the pyramidal formations and to trace the full extent of subsurface voids or tunnel branches. Integration with existing LiDAR and photogrammetric models will aid in predictive excavation planning.

5.4 Cultural and Astronomical Integration

As astronomical alignments continue to emerge as a significant architectural feature, systematic archaeoastronomical surveys—including simulations of celestial movements in prehistoric epochs—should be undertaken. Ethnographic analogs and regional mytho-historical records may also yield context for intentional site orientation and landscape symbolism.

5.5 Open Data and Peer Collaboration

To facilitate broader academic engagement, future research should prioritize transparent, peer-accessible publication of datasets, including all laboratory reports, field logs, and calibration files. The promotion of open scientific dialogue across disciplines—archaeology, geology, physics, and archaeoastronomy—is essential to assess the site's significance with both rigor and neutrality.

6. Conclusion

The Bosnian Valley of the Pyramids presents a unique and complex archaeological landscape whose features warrant serious scientific attention. Through the application of radiocarbon dating, uranium-thorium series analysis, and soil chronology, this study provides a coherent multi-method framework for establishing the temporal depth of key structures within the valley—including the Bosnian Pyramids of the Sun and Moon and the Ravne tunnel systems.

The evidence consistently points toward phases of construction or accessibility that significantly predate the Neolithic period, with calibrated radiocarbon dates as early as **33,800 years BP** for the Pyramid of the Sun and **30,600–34,000 years BP** for embedded organic material in the Ravne tunnels. Meanwhile, the Pyramid of the Moon demonstrates layered human interaction over thousands of years, supported by its integration into astronomical alignments and extensive megalithic terraces. The discovery of Late Antiquity charcoal within Ravne 3 indicates later, secondary human engagement with the site, reaffirming its long-term cultural relevance.

These findings challenge prevailing assumptions about prehistoric activity in the Balkans and highlight the need for continued, transparent, and interdisciplinary research. While questions remain regarding the origin, function, and cultural context of these structures, the robust chronological data establish a factual baseline from which further archaeological, geological, and archaeoastronomical inquiry can proceed.

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Statements

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Competing Interests
The author declares no competing financial or non-financial interests relevant to the content of this article.

Author Contributions
Dr. Sam Osmanagich was solely responsible for the conception, fieldwork coordination, sample collection, literature review, data interpretation, manuscript writing, and submission process.

Ethics Approval and Permissions
All archaeological investigations were conducted with formal approval from the Cantonal Ministry of Culture (Zenica-Doboj Canton) and were carried out in compliance with local cultural heritage protection laws. No human or animal subjects were involved in this study.

Data Availability
All laboratory reports, dating certificates, and field documentation cited in this study are available from the corresponding author upon reasonable request. Select documents are publicly accessible via the Foundation's official archive (http://www.piramidasunca.ba, www.icbp.ba) and booksbydrsam.com.

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LIST OF FIGURES

Figure 1.
The Bosnian Pyramid of the Sun: Aerial view and geomorphological characteristics.
The image presents an aerial perspective of the Bosnian Pyramid of the Sun, located near Visoko in central Bosnia-Herzegovina. Rising to a height of **368 meters**, the structure is distinguished by its prominent **triangular faces**, notably the northern, eastern, and western slopes, which display relatively straight edges and consistent inclinations. Field measurements indicate that the triangular planes exhibit **average inclinations between 42° and 45°**, suggesting significant geometric regularity. The base of the pyramid measures approximately **420 meters per side**, and the apex is slightly displaced, an effect observed in several ancient stepped-pyramid constructions globally. The feature is currently covered by a layer of soil, vegetation, and forest, obscuring potential architectural elements beneath the surface. The geometrical characteristics, combined with its orientation and alignment toward cardinal points, have prompted interdisciplinary investigations into whether the pyramid is a natural, geo-engineered, or anthropogenic formation.
Source: Osmanagich, S. (2014). *Pyramids around the World & Lost Pyramids of Bosnia*. Sarajevo: Archaeological Park: Bosnian Pyramid of the Sun Foundation. ISBN 978-9958-674-01-3, p. 224. Also available as an e-book at: http://www.booksbydrsam.com/books/pyramids-around-the-world-2014.pdf, accessed April 29, 2025.

Figure 2.
Archaeological excavation on the Bosnian Pyramid of the Sun: discovery of large concrete-like blocks beneath soil cover.
The figure presents results from archaeological excavations conducted between 2005 and 2025 by the *Archaeological Park: Bosnian Pyramid of the Sun* Foundation, an organization registered with the State Ministry of Justice of Bosnia-Herzegovina for archaeological, scientific, and cultural heritage activities. Excavations revealed the existence of large, rectangular, concrete-like slabs approximately **one meter beneath the overlying soil and vegetation layer**.

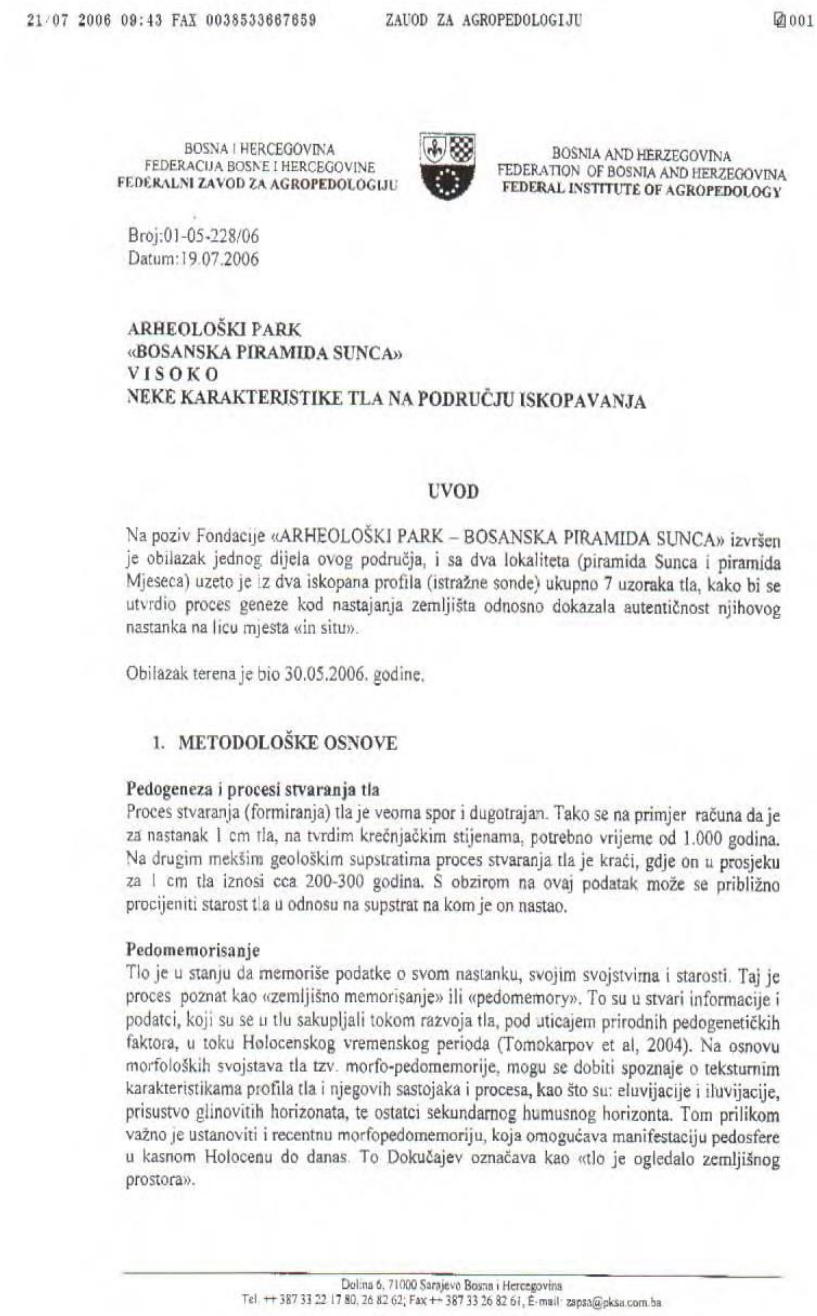
- **Upper left:** Archaeological trench 5, showing exposure of multiple surface plates arranged at shallow angles.
- **Upper right:** Archaeological trench 4C, where massive, interlocking blocks were uncovered, characterized by uniformity and compacted layers.
- **Bottom left:** Archaeological trench 4A, illustrating large slabs set within a compact matrix, excavated by Foundation staff and international volunteers under professional supervision.

- **Bottom right:** Northeastern corner exposure, highlighting the transition from natural overburden to structured material.
  The excavated materials exhibit properties consistent with man-made conglomerate, including high compressive strength and distinct layering, stimulating interdisciplinary debate on potential geoengineering techniques used.
  Source: Osmanagich, S. (2023). *Bosnian Pyramids – My Story*. Sarajevo: Archaeological Park: Bosnian Pyramid of the Sun Foundation. ISBN 978-9958-674-10-5, pp. 16–17. Also available as an e-book at: http://www.booksbydrsam.com/books/my-story-book.pdf, accessed April 29, 2025.

Figure 3.
Pedological study of the Bosnian Pyramid of the Sun and Bosnian Pyramid of the Moon: Preliminary soil characterization and age estimation.
This figure presents the official report prepared by the *Federal Institute of Agropedology* of Bosnia and Herzegovina, based on field surveys and soil sample analyses conducted at the Bosnian Pyramid of the Sun and the Bosnian Pyramid of the Moon. The study involved detailed

observation of exposed profiles and soil stratigraphy to understand the pedogenesis process.
Key findings:

- The soil profile formation rate suggests that the overlying sediment layer would require **12,000–15,000 years** to accumulate based on humus content (1.3–2.9%), clay fraction (42.9%), and average soil depth (40–50 cm) on limestone substrate.
- Pedomemory analysis (soil "memory" of environmental conditions) confirmed the prolonged natural development of soil horizons without significant modern disturbances, indicating the long-term stability and authenticity of the soil cover.
  The study provides a critical scientific basis for dating the anthropogenic modifications underlying the soil layers, suggesting that structures beneath predate conventional historical chronologies for the region.
  Source: Resulović, H., & Čustović, H. (2008). "Pedomemory as a source of information on soil development, processes and age in the function of archaeological investigations," in: *ICBP Proceedings, The First International Scientific Conference on the Bosnian Valley of the Pyramids*, pp. 495–500. ISBN 978-9958-9958-0-4. Publisher: Archaeological Park: Bosnian Pyramid of the Sun Foundation.



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Broj:01-05-228/06
Datum:19.07.2006

ARHEOLOŠKI PARK
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V I S O K O
NEKE KARAKTERISTIKE TLA NA PODRUČJU ISKOPAVANJA

UVOD

Na poziv Fondacije «ARHEOLOŠKI PARK – BOSANSKA PIRAMIDA SUNCA» izvršen je obilazak jednog dijela ovog područja, i sa dva lokaliteta (piramida Sunca i piramida Mjeseca) uzeto je iz dva iskopana profila (istražne sonde) ukupno 7 uzoraka tla, kako bi se utvrdio proces geneze kod nastajanja zemljišta odnosno dokazala autentičnost njihovog nastanka na licu mjesta «in situ».

Obilazak terena je bio 30.05.2006. godine.

1. **METODOLOŠKE OSNOVE**

Pedogeneza i procesi stvaranja tla
Proces stvaranja (formiranja) tla je veoma spor i dugotrajan. Tako se na primjer računa da je za nastanak 1 cm tla, na tvrdim krečnjačkim stijenama, potrebno vrijeme od 1.000 godina. Na drugim mekšim geološkim supstratima proces stvaranja tla je kraći, gdje on u prosjeku za 1 cm tla iznosi cca 200-300 godina. S obzirom na ovaj podatak može se približno procijeniti starost tla u odnosu na supstrat na kom je on nastao.

Pedomemorisanje
Tlo je u stanju da memoriše podatke o svom nastanku, svojim svojstvima i starosti. Taj je proces poznat kao «zemljišno memorisanje» ili «pedomemory». To su u stvari informacije i podatci, koji su se u tlu sakupljali tokom razvoja tla, pod uticajem prirodnih pedogenetičkih faktora, u toku Holocenskog vremenskog perioda (Tomokarpov et al, 2004). Na osnovu morfoloških svojstava tla tzv. morfo-pedomemorije, mogu se dobiti spoznaje o teksturnim karakteristikama profila tla i njegovih sastojaka i procesa, kao što su: eluvijacije i iluvijacije, prisustvo glinovitih horizonata, te ostatci sekundarnog humusnog horizonta. Tom prilikom važno je ustanoviti i recentnu morfopedomemoriju, koja omogućava manifestaciju pedosfere u kasnom Holocenu do danas. To Dokučajev označava kao «tlo je ogledalo zemljišnog prostora».

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Figure 4.
Radiocarbon dating of organic material discovered on the surface of artificial concrete blocks on the Bosnian Pyramid of the Sun.
In 2012, during excavation work led by the *Archaeological Park: Bosnian Pyramid of the Sun*

Foundation, Italian archaeologists Niccolo Bisconti and Ricardo Brett uncovered a piece of organic material embedded between the surface layers of large concrete blocks on the Bosnian Pyramid of the Sun. The sample was submitted for radiocarbon dating to the *Conventional Radiocarbon Dating Service Laboratory* in Kyiv, Ukraine.

The laboratory result yielded a **radiocarbon age** of **24,800 ± 200 years Before Present (BP)**. This uncalibrated radiocarbon date indicates the minimum age of the surface layer and suggests possible prehistoric construction activity at the site. Calibration would adjust this date further back into the Late Pleistocene, but even the raw radiocarbon result is exceptional for European prehistoric archaeology.

The analysis was performed under laboratory code **IME-1814** using standard beta-counting techniques.

Source: Brett, R. *Archaeological Report for 2012*, published in: Osmanagich, S. *Bosnian Pyramids – My Story* (2023), p. 112–113. Available online: http://www.booksbydrsam.com/books/my-story-book.pdf, accessed April 29, 2025.

Conventional radio carbon dating service laboratory. Kiev.

Радіовуглецева дата (Radiocarbon date)

Замовник (Customer)	Foundation "Archaeological park "Bosnian Pyramid of the Sun"	
Зразок(Sample)	Soil deposition with organic matter	02-BPS-4A-2012
Код лабораторії (lab code)	IIME-1814	
Маса бензолу (benzene mass)	0,739	грам (g)
Час вимірювання (counting time)	3000	хвилин (minutes)
Швидкість лічення проби (Sample count rate)	0.357	CPM
Фон (зам./хв.) (Background count rate)	0.109	CPM
Ефективність реєстрації (counting efficiency) :	58,55%	Процент (percent)
Радіовуглецева дата (Radiocarbon date)	24800 ± 200	BP
Калібрована дата (Calibrated date)	-	

Michael G Buzinny

18.08.2012

Figure 5.
Radiocarbon dating of organic material associated with soil deposition on the Bosnian Pyramid of the Sun.
During the 2013 archaeological season organized by the *Archaeological Park: Bosnian Pyramid of the Sun Foundation*, organic material embedded within a carbonate soil deposit was uncovered on the western slope of the Bosnian Pyramid of the Sun. The sample, labeled **BP-Sun-S12-2013-01**, was analyzed by the *Conventional Radiocarbon Dating Service Laboratory* in Kyiv, Ukraine.
The radiocarbon dating result was **29,200 ± 400 years Before Present (BP)** (uncalibrated).
The material, containing carbonates and organic residue, suggests ancient environmental processes or early anthropogenic influence on the site.
The laboratory analysis, conducted under code **IHME-2177**, applied standard conventional radiocarbon dating methodology.
Source: First published in the *Archaeological Report: Season 2013* by the Foundation's archaeological manager Tim Moon, accessible at the Foundation's official website: http://arhiva.piramidasunca.info/bs/konferencije/item/8976-archaeological-report-season-2013-2.html, accessed April 29, 2025.
Subsequently published in Osmanagich, S., *Bosnian Pyramids – My Story* (2023), p. 184, Archaeological Park: Bosnian Pyramid of the Sun Foundation, Visoko, and available online at www.icbp.ba, accessed April 29, 2025.

Conventional radio carbon dating service laboratory. Kiev

Замовник (Customer) Foundation
"Archaeological park "Bosnian Pyramid of the Sun"

Зразок (Sample): Soil deposition with CARBONATE BPSun-S12 -2013-01
Код лабораторії (lab code) IHME -2177

Маса бензолу (benzene mass) 0,510 грам (g)

Час вимірювання (counting time) 3000 хвилин (minutes)
Швидкість лічення проби (Sample count rate) 0.295 CPM
Фон (імп./хв.) (Background count rate) 0.173 CPM
Ефективність реєстрації (counting efficiency) : 71,52% Процент (percent)
Радіовуглецева дата (Radiocarbon date) 29200 ± 400 BP
Калібрована дата (Calibrated date)

Figure 6.
Dr. Paul LaViolette presents the projected calibrated age of the Bosnian Pyramid of the Sun based on radiocarbon analysis.
Dr. Paul A. LaViolette, Ph.D., physicist and systems theorist, delivered a lecture at the *International Scientific Conference on Bosnian Pyramids* proposing a calibrated age for the Bosnian Pyramid of the Sun.
Building upon the uncalibrated radiocarbon date of **29,200 ± 400 years BP**, Dr. LaViolette projected a calibrated age range of approximately **33,800–34,000 years Before Present (cal BP)**.
He highlighted that this places the construction of the structure well into the Upper Paleolithic period, suggesting the possibility of a technically advanced Ice Age civilization.
Dr. LaViolette, known for his interdisciplinary research into astrophysics, ancient technologies, and geomythology, is the author of books such as *Earth Under Fire* and *Subquantum Kinetics*.
Source: Nexus Magazine, "New Findings at the Bosnian Pyramids Complex – Part 2" (https://nexusmagazine.com/product/new-findings-at-the-bosnian-pyramids-complex-part-2/) and archived lecture summary at http://arhiva.piramidasunca.info/bs/konferencije/item/9520-dr-

paul-laviolette-phd-bosnian-pyramid-complex-signs-of-technically-advanced-ice-age-civilization-1.html, accessed April 29, 2025.

Diagram: Step-by-Step Dating of the Bosnian Pyramid of the Sun

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Step 1: Field Archaeological Discovery

- Excavations revealed large, artificially-made concrete blocks.
- Blocks were located approximately 1 meter beneath the surface soil.

Step 2: Soil Analysis by Federal Institute for Agropedology (2006)

- Soil layer on top of the pyramid dated to **12,000–15,000 years** based on pedogenesis and humus content.
- Conclusion: The pyramid must be **older** than the soil above it.

Step 3: First Radiocarbon Dating (2012)

- Organic material found between concrete layers.
- Radiocarbon result: **24,800 ± 200 years BP** (Before Present, uncalibrated).
- Indicates a **minimum age** for the construction phase.

Step 4: Second Radiocarbon Dating (2013)

- Another sample from carbonate-rich material.
- Radiocarbon result: **29,200 ± 400 years BP** (uncalibrated).
- Sample analyzed by laboratory in Kiev.

Step 5: Calibration to Calendar Years

- Calibration of radiocarbon results required due to atmospheric variation in C-14 levels.
- Based on calibration, **29,200 BP** corresponds to approximately **33,800–34,000 calibrated years BP**.

Step 6: Expert Assessment (Dr. Paul LaViolette)

- Review and projection of calibrated dates.
- Supports interpretation that pyramid construction dates to the late Pleistocene (~33,800 years ago).

Conclusion:

Based on combined archaeological, soil science, and radiocarbon dating evidence, the **Bosnian Pyramid of the Sun** is approximately **33,800 years old**, making it one of the oldest known monumental structures on Earth.

+++

Figure 7. *Bosnian Pyramid of the Moon, Visoko Valley, Bosnia-Herzegovina.* This pyramid-shaped elevation stands approximately **190 meters** high and is clearly **oriented to the cardinal points**. The photograph, taken on **August 21**, shows the western slope under partial cloud cover with spring vegetation in view. On this date, during **sunset**, the **shadow of the Bosnian Pyramid of the Sun** moves across the valley and **completely envelops the western face** of the Moon pyramid. At the final moment of sunset, the top of the shadow **precisely aligns with the summit** of the Bosnian Pyramid of the Moon. This phenomenon demonstrates a likely **astronomical alignment**, suggesting intentional placement and height of these two prominent structures in the valley.

Source: Osmanagich, S. *My Story: Bosnian Pyramids*, 2023, p. 258. Archaeological Park: Bosnian Pyramid of the Sun Foundation. ISBN 978-9958-674-10-5. Also available online: www.booksbydrsam.com, accessed April 29, 2025.

Figure 8. *Bosnian Pyramid of the Moon – Archaeological Excavations.* Archaeological works conducted between 2006 and 2024 by the "Archaeological Park: Bosnian Pyramid of the Sun" Foundation have exposed **paved sandstone terraces** across the structure's slopes. A total of **64 archaeological trenches** have been opened, extending from the **base to the summit**, confirming that the entire pyramid is layered with **angular sandstone plates**. These tiles are separated by alternating layers of clay, possibly serving as a binder or insulator. The photographs show various excavation stages, including terraced tiling, stratified construction techniques, and detailed trench profiles with measurable **layering sequences**. This evidence supports the interpretation of the pyramid as an artificial or artificially modified structure of great antiquity.

Source: Osmanagich, S. *My Story: Bosnian Pyramids*, 2023, p. 258. Archaeological Park: Bosnian Pyramid of the Sun Foundation. ISBN 978-9958-674-10-5. Accessed online: www.booksbydrsam.com, April 29, 2025.

Figure 9. Radiocarbon Dating of the Paved Terrace on the Bosnian Pyramid of the Moon

Upper panels: Organic sample being extracted from the brown deposit located between two bonded sandstone layers forming a paved terrace on the western face of the Bosnian Pyramid of the Moon (Archaeological trench No. 20). This material was likely trapped during construction and later subjected to radiocarbon dating.

Lower panel: Radiocarbon dating analysis conducted by the Institute of Physics of Silesian University of Technology in Gliwice, Poland, under the supervision of Prof. Anna Pazdur. The sample was dated to **10,350 ± 50 BP**, which calibrates to a range between **10,458 and 10,074 calBC** (95.4% probability), confirming the terrace was constructed more than 12,000 years ago.

Source: Brett, R. and Osmanagich, S., sample collected in 2010; published in the "Archaeological Report – Season 2010," accessible at http://arhiva.piramidasunca.info/bs/konferencije/item/8976, and also in *My Story*, p. 258. Graph retrieved from dating report (Graph 1, Bosnia Valley 2, 10350±50).

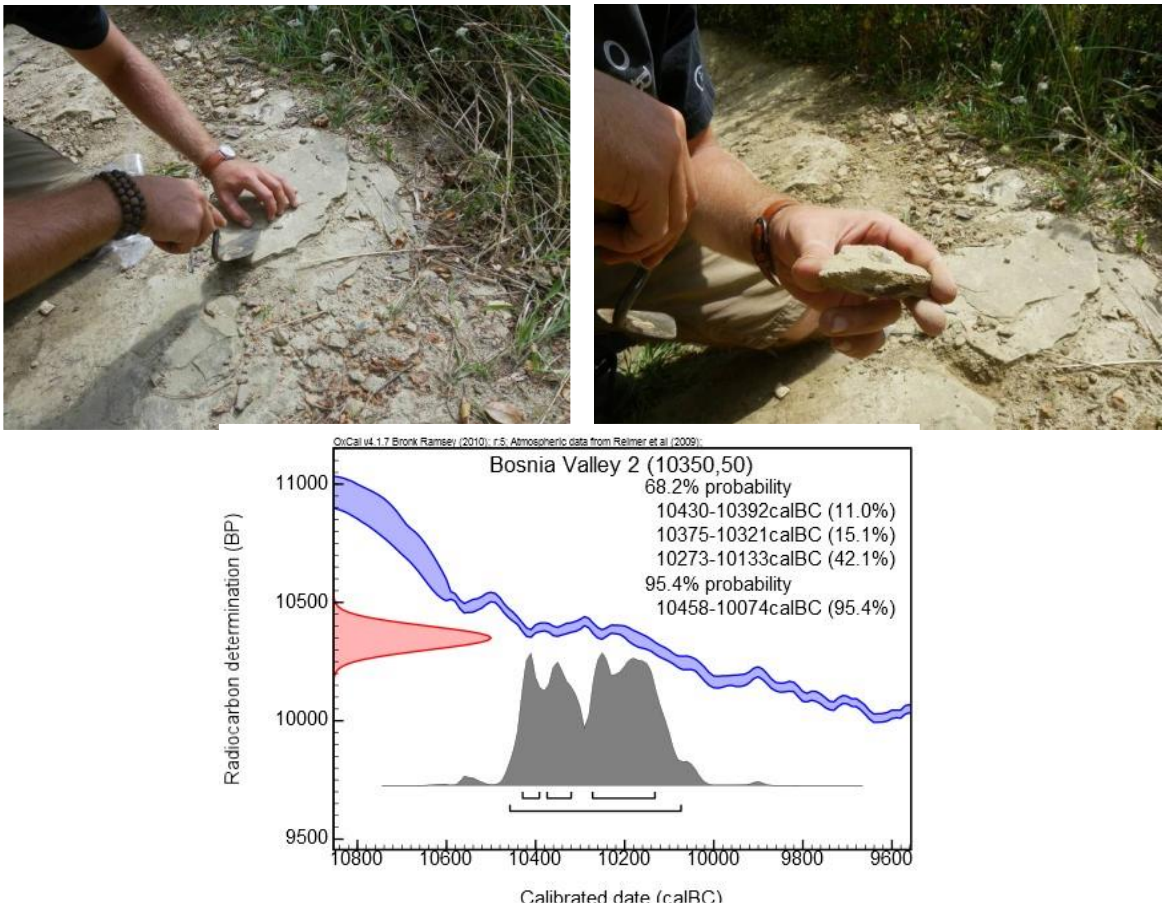

Figure 10. Ravne Tunnel Labyrinth

The Ravne tunnel complex is part of an extensive prehistoric underground network in the Visoko Valley, Bosnia-Herzegovina. Since excavation efforts began in 2006, over **2.6 kilometers** of tunnels have been cleared of loosely packed filler material. Archaeological work conducted by the "Archaeological Park: Bosnian Pyramid of the Sun" Foundation has revealed numerous structural and cultural elements, including:

- Upper left: Original tunnel passageway exhibiting consistent dimensions and curvature.

- Upper right: One of more than **50 dry-stone walls** constructed with inclined stone layers, interpreted as ancient support or sealing structures.
- Bottom left and right: Two of the five **megalithic ceramic blocks**, weighing up to several tons, found embedded in the tunnel floor. These enigmatic sandstone formations are hypothesized to be markers, energy amplifiers, or geodetic artifacts.

Source: Osmanagich, S. *Bosnian Pyramids – My Story* (2023), pp. 58–65. Published by Archaeological Park: Bosnian Pyramid of the Sun Foundation. Also accessible online: http://www.booksbydrsam.com/books/my-story-book.pdf, accessed April 29, 2025.

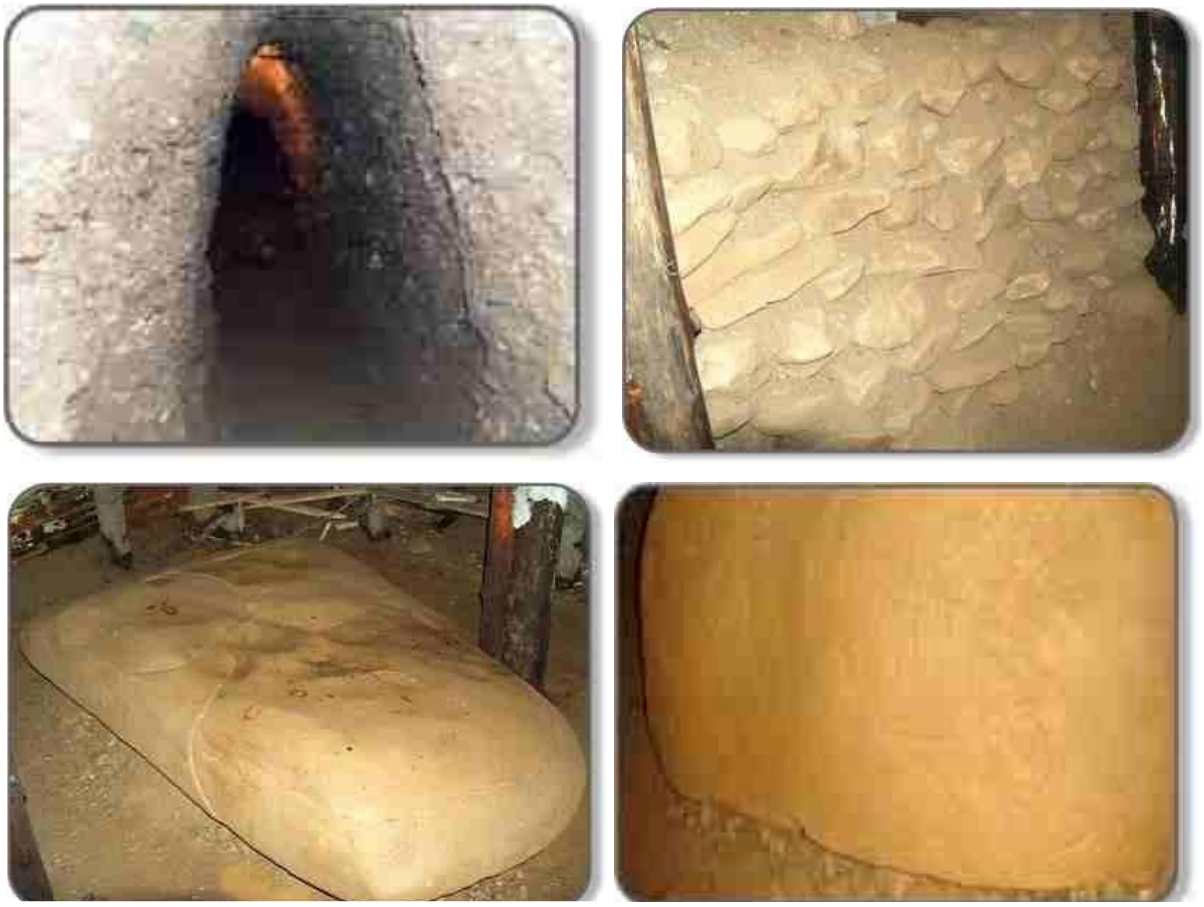

Figure 11. Radiocarbon Dating of Organic Material in Ravne Tunnel Complex

Left: Testing of organic material samples collected from the Ravne tunnel complex in Visoko was conducted using the **Accelerator Mass Spectrometry (AMS)** method. The analysis, carried out at the Institute of Physics, Silesian University of Technology in Gliwice, Poland, produced a radiocarbon date of **4610 ± 35 years BP**, corresponding to approximately **2660 BCE**. The AMS method, which counts all carbon-14 atoms (not just those in decay), allows for more precise age determination than conventional radiocarbon techniques.

Right: At the base of a dry-stone wall in the tunnel system, the Foundation team discovered remnants of an ancient fireplace. Organic materials from this location were sent to the **Ångström Laboratory at Uppsala University, Sweden**, for testing. The resulting radiocarbon age of the sample found 180 meters from the entrance was **3091 ± 111 years BP**, or approximately **1140 BCE**.

These findings support the hypothesis that the tunnel complex was **in active use across multiple prehistoric periods**, likely constructed or adapted in phases.

Source: Osmanagich, S. *Pyramids Around the World and Lost Pyramids of Bosnia* (2014), pp. 227–230. Archaeological Park: Bosnian Pyramid of the Sun Foundation. ISBN: 978-9958-674-01-3. Also available as e-book: http://www.booksbydrsam.com/books/pyramids-around-the-world-2014.pdf, accessed April 29, 2025.

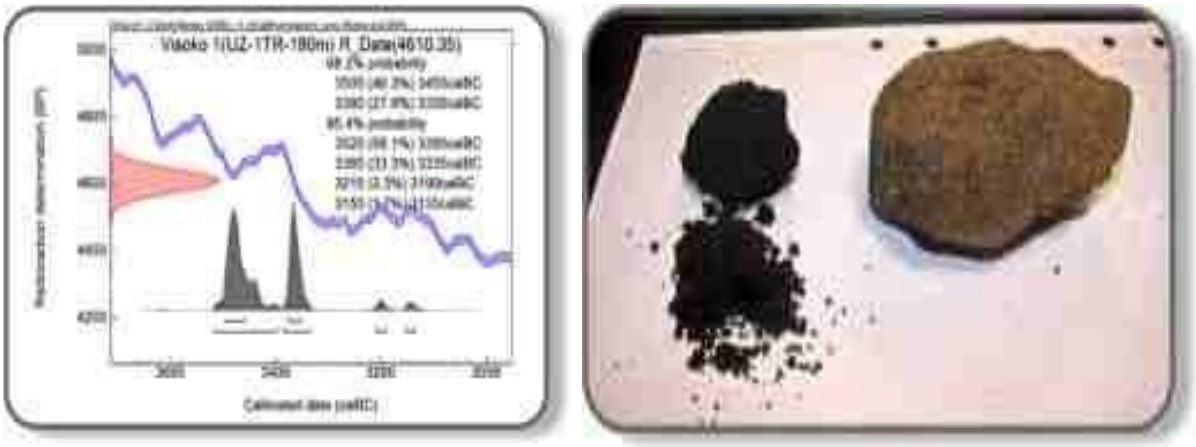

Figure 12. Wood Sample Embedded in Conglomerate: Radiocarbon Dating and Stratigraphic Implications

Left: A piece of fossilized wood (approx. **35 x 18 x 12 cm**) was uncovered embedded in the compact conglomerate matrix within the Ravne Tunnel labyrinth. Its position within this

geologically stable material, which accumulated over tens of thousands of years, offers critical evidence for dating early human activity in the Visoko Valley.

Right: Two independent radiocarbon analyses were performed on samples from this wood specimen:

- At the **Department for Radioisotopes, Institute of Physics, Silesian University of Technology in Gliwice (Poland)**, the sample yielded an age of **34,000 ± 1,500 years BP**.
- A second sample was analyzed at the **Leibniz Laboratory for Radiometric Dating and Isotope Research**, **Christian-Albrechts University, Kiel (Germany)**, producing a result of **30,600 ± 540/510 years BP**.

These results were announced during the **First International Scientific Conference on the Bosnian Valley of the Pyramids** in August 2008. As the wood was embedded in naturally compacted conglomerate, the dated samples predate its formation, indicating substantial antiquity for the tunnel structures and associated megalithic features. The presence of these large sandstone blocks beneath such geological layers suggests the existence of a **Paleolithic-era civilization**, consistent with regional genetic evidence for early Homo sapiens migration through the Balkans.

Source: Lawler, A. *AMS Radiocarbon Dating of a Wood Sample from Tunnel Ravne: Methods, Results and Implications for Further Research*. In: *ICBP Proceedings: The First International Scientific Conference on the Bosnian Valley of the Pyramids*, 2008, pp. 681–682.

Figure 13. Ravne 3 Tunnel Complex: Prehistoric Construction Features and Geological Indicators

Top left: Engineered circular tunnel segment carved through dense conglomerate and filled with compacted material. Its uniform curvature and consistent width suggest intentional prehistoric construction and planning.

Top right: Dry-stone wall discovered in Ravne 3 during the 2022 excavation season. Stacked sandstone plates embedded within tunnel sides reflect organized structural techniques used to stabilize or redirect interior spaces.

Bottom left: Stalagmites and other calcite formations growing directly on exposed surfaces within the tunnel system. These features point to long-term undisturbed conditions following initial construction.

Bottom right: Cross-section of a stalagmite recovered from Ravne 3. The formation's distinct internal layering and degree of mineralization provide visual evidence for significant age, marking long periods of environmental stability within the tunnel.

These findings contribute to the interpretation of Ravne 3 as an intentionally engineered subterranean structure abandoned in antiquity and left to natural geological development.

Source: Osmanagich, S., Hoyle, R., Agić, A., Delibašić, H. *Ravne 3*. Visoko: Archaeological Park: Bosnian Pyramid of the Sun Foundation, 2023, pp. 51, 54, 57, 235.

Figure 14. Stalagmites S001 and S002 Discovered in Tunnel Ravne 3

Two cone-shaped stalagmites (S001 and S002) were found at the same stratigraphic level in Tunnel Ravne 3. These speleothems were sampled for geochronological analysis to help estimate the tunnel's minimum age.

Stalagmite S001 was dated using radiocarbon (C-14) analysis and yielded an apparent age of **26,200 ± 250 years**, although this result is likely distorted due to the presence of "dead carbon" from dissolved carbonate ions in the conglomerate bedrock. The base of the stalagmite was not dated, meaning the true age may be greater.

Stalagmite S002 was dated using Uranium-Thorium (U-Th) ICP-MS analysis, yielding a more reliable age of **5,900 ± 300 years**, as U-Th dating is unaffected by carbonate contamination in the same way as radiocarbon methods.

Despite their proximity and similar morphology, the large discrepancy in the results highlights methodological differences and challenges with speleothem dating. The U-Th age for S002 serves as a **minimum age** for the cessation of human activity in that area of the tunnel.

Source: Osmanagich, S., Hoyle, R., Agić, A., Delibašić, H. *Ravne 3* (2023), pp. 84–88. Publisher: Archaeological Park: Bosnian Pyramid of the Sun Foundation, Visoko.

Figure 15. Radiocarbon Analysis of Samples from Tunnel Ravne 3: Laboratory Procedures and Results

This table presents the radiocarbon dating results obtained for multiple samples collected from the Ravne 3 Tunnel Complex in Visoko, Bosnia-Herzegovina. The analyses were conducted by the **Laboratory for Radiocarbon Dating, Institute of Environmental Geochemistry, National Academy of Sciences of Ukraine, Kyiv**.

Laboratory Methods and Approach:

The conventional radiocarbon dating method was employed, based on **liquid scintillation counting** of benzene samples. The laboratory procedure involved the following steps:

- **Sample Preparation:** Organic and carbonate materials were sought in each sample.
- **Thermal Destruction (Vacuum Pyrolysis):** Samples were subjected to vacuum pyrolysis at 250°C for three hours to release measurable carbon. If residual charred carbon was visually detected, it indicated the presence of organic matter.
- **Chemical Conversion:** In cases of carbonate presence, chemical reactions were applied:
    - CO_2 was liberated through acid destruction.
    - CO_2 was then reacted with lithium to form lithium carbide.

    - Lithium carbide was further processed into acetylene and then into benzene ($C + Li \rightarrow Li_2C_2 \rightarrow C_2H_2 \rightarrow C_6H_6$).
- **Measurement:** Radiocarbon content was determined by measuring radioactivity within the benzene samples using liquid scintillation counting.

Results Overview:

- Samples **C2-018** and **C2-025** initially showed no datable organic carbon through pyrolysis. However, carbonate acid destruction allowed the production of benzene and successful radiocarbon dating:
    - **Sample C2-018** (sandstone-like material) produced a relatively higher benzene yield.
    - **Sample C2-025** (pressed clay-like material) produced less benzene.
- Sample **C2-024**, interpreted as a possible bird bone fragment, contained no measurable organic carbon and could not be dated.
- **Stalagmite sample S001** was carefully stratified into layers (A, B, and C). Carbon analysis was conducted separately for external and internal sections:
    - Layer A and Layers B+C were individually processed and dated.
    - Additional cross-sections were taken for precision, producing multiple protocol results.

Radiocarbon Dating Results (summarized in Table):

The results indicate a complex chronology for the tunnel, with radiocarbon dates ranging from the late Upper Paleolithic (26,200 years BP) to more recent Holocene periods (ca. 3,000–4,000 years BP). These findings suggest multiple phases of use and environmental changes within the Ravne 3 system.

Source: Osmanagich, S., Hoyle, R., Agić, A., Delibašić, H. (2023). *Ravne 3,* Archaeological Park: Bosnian Pyramid of the Sun Foundation, pp. 84–88.

Lab No.	Description	Benzene (g)	pMC (%)	Age (years BP)
3729	S001 Layers (B+C)	1.3853	64.5	3520 ± 50
3730	S001 Layers (A)	0.694	72.9	2540 ± 50
3732	S001 Layers (C)	1.2285	61.7	3880 ± 55
3733	S2-018	1.3183	68.3	3070 ± 50
3734	S001 Layers (B) A	1.0192	3.8	26200 ± 250
3735	S2-025	0.149	26.7	10625 ± 300

Замовник (Customer)	Foundation "Archaeological park	”Bosnian Pyramid of the Sun"
Зразок(Sample):	Sample S001 (layer B, top)	(carbonate)
Код лабораторії (lab code)	IHME-3734	
Маса бензолу (benzene mass)	1,0192	грам (g)
Час вимірювання (counting time)	3000	хвилин (minutes)
Швидкість лічення проби (Sample count rate)	0.87	CPM
Фон (імп./хв.) (Background count rate)	0.506	CPM
Ефективність реєстрації (counting efficiency) :	73,51%	Процент (percent)
Радіовуглецева дата (Radiocarbon date)	26200 ± 250	BP
Калібрована дата (Calibrated date)	-	

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Figure 16. Uranium-Thorium Dating of Stalagmites from Ravne 3 Tunnel Complex

This figure presents the results of U-series dating of stalagmite samples collected from the Ravne 3 Tunnel Complex in Visoko, Bosnia-Herzegovina. The analyses were performed using **uranium-thorium (U-Th) isotopic dating methods**, a technique particularly well suited for dating calcium carbonate formations such as stalagmites.

Laboratory Methods and Facilities:

- **Chemical Processing:** After thermal decomposition of organic matter, a ^233U–^236U–^229Th spike was added to each sample. The samples were then dissolved in nitric acid, and uranium and thorium were chemically separated from the carbonate matrix using chromatographic extraction with **TRU-resin**.
- **Laboratories Involved:**
  - **U-series Laboratory of the Institute of Geological Sciences, Polish Academy of Sciences** (Warsaw, Poland) conducted the chemical separations.

- **Institute of Geology of the Czech Academy of Sciences (CAS)** (Prague, Czech Republic) conducted the isotopic measurements using a **double-focusing sector-field ICP mass spectrometer** (Element 2, Thermo Finnigan MAT).

All measurements were corrected for background radiation and chemical blanks. Standard reference materials and blank samples were run in parallel with the test samples to ensure analytical accuracy.

Dating Results:

- **Sample US001** (from a lower stalagmite layer) was dated to **19,000 ± 1,000 years BP**.
- **Sample S008**, analyzed with the same method, yielded an age of **15,000 ± 1,000 years BP**.
- An additional stalagmite sample, **S002**, yielded a U-Th age of **5,900 ± 200 years BP**. This sample had previously been dated using radiocarbon methods, which produced divergent results due to the "dead carbon" effect commonly associated with speleothem samples in carbonate-rich contexts.

Interpretation:

The considerable variation in the ages of stalagmite layers (ranging from ~5,900 to ~19,000 years BP) is attributed to differences in sample depth, layering, and sample selection. For example, deeper stalagmite layers are logically older and less likely to have been disturbed by anthropogenic activity or environmental contaminants. These results collectively support the interpretation that human or environmental influence on tunnel stability and inactivity dates back well into the **Upper Paleolithic**.

Conclusion:

These U-series dating results underscore the need for continued stratified sampling and analysis of the extensive stalagmite formations preserved in **Section A and A2** of Ravne 3. The chronological depth indicated by these measurements is of significant importance for understanding the long-term geochronology and potential anthropogenic activity associated with the Ravne tunnel system.

Source: Osmanagich, S., Hoyle, R., Agić, A., Delibašić, H. (2023). *Ravne 3,* Archaeological Park: Bosnian Pyramid of the Sun Foundation, pp. 126–128.
Laboratory report: Institute of Geology CAS (Prague, Czech Republic) & Institute of Geological Sciences, Polish Academy of Sciences (Warsaw, Poland).

U-series dating report

Samples quantity: 2

Material: calcite powder

Method description:

Chemical procedure of uranium and thorium separation

After thermal decomposition of organic matter a ^{233}U-^{236}U-^{229}Th spike is added to samples before any further chemical treatment. Sample is dissolved in nitric acid. Uranium and thorium is separated from carbonate matrix using chromatographic method with TRU-resin Chemical procedure has been done in U-series Laboratory of Institute of Geological Sciences, Polish Academy of Sciences (Warsaw, Poland). Internal standard sample and blank sample were prepared simultaneously any series of studied samples.

Measurement

Isotopic composition of U and Th measurement has been performed in Institute of Geology of the CAS, v. v. i. (Prague, Czech Republic). Measurements were performed with a double-focusing sector-field ICP mass analyzer (Element 2, Thermo Finngan MAT). The instrument was operated at a low mass resolution ($m/\Delta m \geq 300$). Measurement results were corrected for counting background and chemical blank.

Results:

Lab. no.	Sample	U cont. [ppm]	$^{234}U/^{238}U$ AR	$^{230}Th/^{234}U$ AR	$^{230}Th/^{232}Th$ AR	Age [ka]	*Corrected age [ka]	**Initial $^{234}U/^{238}U$ AR
1518	US 001	0.0277±0.0001	1.2743±0.0053	0.2581±0.0053	1.823±0.037	32.38±0.76	19±1	1.296±0.068
1519	S008 (a)	0.0458±0.0002	1.2334±0.0049	0.2308±0.0050	1.696±0.037	28.54±0.71	15±1	1.243±0.083

Calculations use the decay constant of Jaffey et al., 1971 (^{238}U), Cheng et al., 2013 (^{234}U and ^{230}Th) and Holden, 1990 (^{232}Th). Ages do not include uncertainties associated with decay constants.
AR – activity ratio;
* Corrected ages using typical silicate activity ratio $^{230}Th/^{232}Th = 0.83 \pm 0.42$ derived from the $^{232}Th/^{238}U$ activity ratio = 1.21 ± 0.6, $^{230}Th/^{238}U$ activity ratio = 1.0 ± 0.1, and $^{234}U/^{238}U$ activity ratio = 1.0 ± 0.1 (e.g., Cruz et al., 2005).
** Calculated based on $^{234}U/^{238}U$ AR corrected for detrital contamination and corrected age.

Cheng H, Edwards RL, Shen C-C, Polyak VJ, Asmerom Y, Woodhead J, Hellstrom J, Wang Y, Kong X, Sp C, Wang X, Alexander EC. 2013. Improvements in 230Th dating, 230Th and 234U half-live values, and U-Th isotopic measurements by multi-collector inductively coupled plasma mass spectrometry. Earth and Planetary Science Letters 371-372: 82-91.
Cruz Jr., F., W., Burns, S.J., Karmann, I., Sharp, W.D., Vuille, M., Cardoso, A.O., Ferrari, J.A., Dias, P.L.S., Viana Jr., O., 2005. Insolation-driven changes in atmospheric circulation over the past 116,000 years in subtropical Brazil. Nature 434, 63–65.
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Figure 17. Charcoal Radiocarbon Dating from Ravne 3 Tunnel Complex

Charcoal remains were discovered near a dry-stone wall within the Ravne 3 tunnel system. The sample, labeled **S001**, was recovered during supervised excavation in late 2023 and submitted for radiocarbon analysis in early 2024. The purpose of the test was to determine whether this material was related to recent human activity or ancient tunnel use.

The analysis was conducted at the **1 MV Accelerator Mass Spectrometry (AMS) Laboratory** at **TÜBİTAK Marmara Research Center (MRC)**, Gebze, Turkey. The lab employed the **Acid-Base-Acid (ABA) pretreatment** protocol followed by AMS dating. Calibration of the radiocarbon age used the **IntCal20 Northern Hemisphere calibration curve**.

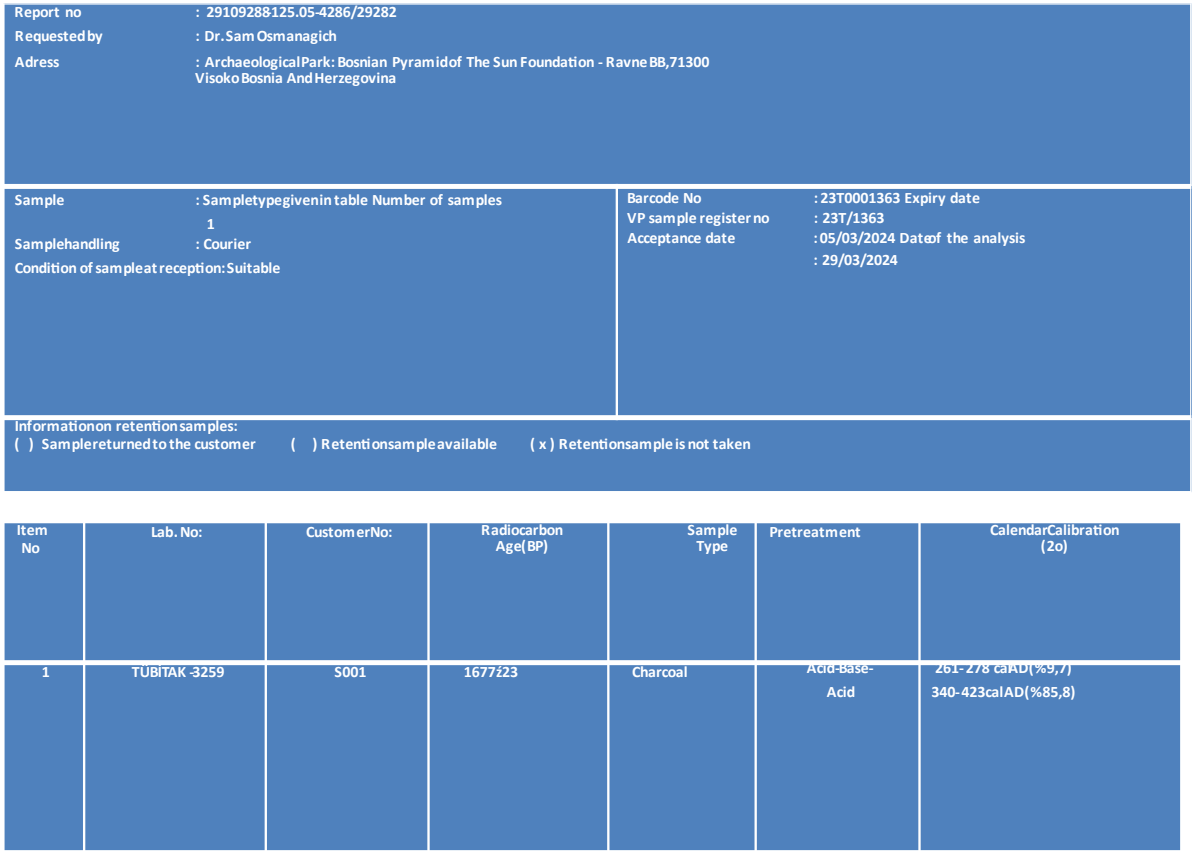
Radiocarbon Dating Results:

- **Radiocarbon Age:** 1677 ± 23 BP
- **Calibrated Calendar Age (2σ range):**
  - 261–278 CE (9.7% probability)
  - 340–423 CE (85.8% probability)

These results suggest that the charcoal dates to the **4th–5th century CE**, indicating human presence in the Ravne 3 tunnel during **late antiquity**. The age places this activity well after the hypothesized original construction of the tunnel system, implying **secondary use or visitation** of already-existing passages. This aligns with field observations of localized disturbance and reopening of sealed sections.

Source:
TÜBİTAK MRC AMS Laboratory Report No. 29109288-125.05-4286/29282, dated April 2, 2024. Sample submitted by Dr. Sam Osmanagich on behalf of the *Archaeological Park: Bosnian Pyramid of the Sun Foundation*.
Published references include:

- Doğan et al. (2023). "Radiocarbon Analysis and Status Report from Türkiye: 1 MV National AMS Laboratory (TÜBİTAK-AMS)." *Radiocarbon*.
- Reimer et al. (2020). "IntCal20 Northern Hemisphere Radiocarbon Age Calibration Curve." *Radiocarbon*, 62(4), 725–757.



Report no	: 29109288125.05-4286/29282
Requested by	: Dr. Sam Osmanagich
Adress	: Archaeological Park: Bosnian Pyramid of The Sun Foundation - Ravne BB, 71300 Visoko Bosnia And Herzegovina

Sample	: Sample type pegiven in table Number of samples 1	Barcode No	: 23T0001363 Expiry date
Sample handling	: Courier	VP sample register no	: 23T/1363
Condition of sample at reception: Suitable		Acceptance date	: 05/03/2024 Date of the analysis : 29/03/2024

Information on retention samples:
( ) Sample returned to the customer ( ) Retention sample available (x) Retention sample is not taken

Item No	Lab. No:	Customer No:	Radiocarbon Age (BP)	Sample Type	Pretreatment	Calendar Calibration (2σ)
1	TÜBİTAK -3259	S001	1677±23	Charcoal	Acid-Base-Acid	261-278 calAD(%9,7) 340-423calAD(%85,8)

Figure 18. Radiocarbon Dating of Calcite Crystal Formation from Ravne Tunnel Water Section

This figure presents the **calibrated radiocarbon dating** result of a **calcite crystal sample** collected from the **water section of the Ravne tunnel** in the Bosnian Valley of the Pyramids complex. The sample originated from **soluble calcite deposits** transported by water from the surface, forming **stalactitic features** on the ceiling of an open section of the tunnel. The calcite structure was characterized by a **waveform-like appearance**, measuring up to **120 mm in length and 100 mm in width**, tapering to a point at the terminal end.

The sample was submitted to **Beta Analytic Radiocarbon Dating Laboratory** (Miami, Florida, USA), where it underwent standard pre-treatment, confirming its formation from **precipitated calcite** rather than organic material. Radiocarbon dating was performed using **conventional liquid scintillation counting**, with isotopic adjustment via **δ13C correction** and final calibration using the **IntCal13 curve**.

- **Laboratory ID:** Beta-388849
- **Conventional Radiocarbon Age:** 6450 ± 30 BP
- **Calibrated Result (95.4% probability):**
  Cal BC 5480 to 5365 (Cal BP 7430 to 7315)

This result indicates that the **crystal formation began approximately 7,430 years ago**, providing a **minimum date for exposure of the tunnel ceiling to percolating water and surface-connected hydrological activity**. Such a date also implies that this portion of the Ravne tunnel system was **already hollow and accessible at that time**, further substantiating its prehistoric origin.

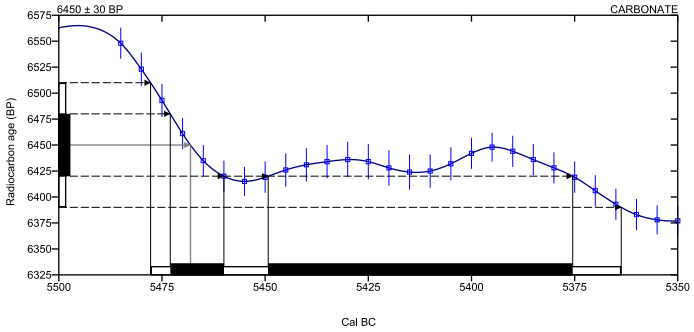
Source:

- Beta Analytic Radiocarbon Dating Certificate, Sample Beta-388849
- Sample origin and analysis details submitted in April 2024 to the Archaeological Park Foundation
- Calibration method: IntCal13; Reimer et al., *Radiocarbon* 55(4):1869–1887.

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12 = -10.5 o/oo : lab. mult = 1)

Laboratory number	**Beta-388489**
Conventional radiocarbon age	**6450 ± 30 BP**
2 Sigma calibrated result 95% probability	**Cal BC 5480 to 5365 (Cal BP 7430 to 7315)**
Intercept of radiocarbon age with calibration curve	Cal BC 5470 (Cal BP 7420)
1 Sigma calibrated results 68% probability	Cal BC 5475 to 5460 (Cal BP 7425 to 7410) Cal BC 5450 to 5375 (Cal BP 7400 to 7325)



Database used
INTCAL13

References

Mathematics used for calibration scenario
A Simplified Approach to Calibrating C14 Dates, Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

References to INTCAL13 database
Reimer PJ et al. IntCal13 and Marine13 radiocarbon age calibration curves 0–50,000 years cal BP. Radiocarbon 55(4):1869–1887.

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