https://doi.org/10.37710/plural.v11i2_4

# RADIOCARBON DATING OF CREMATED BONE SAMPLES FROM THE SITE OF THE HUNGARIAN CHURCH AT PĂUCA, SIBIU COUNTY[1]

**Ioan Marian ȚIPLIC, Corina Anca SIMION, Oana GÂZA, Tiberiu Bogdan SAVA, Cristian MANAILESCU, Maria Valentina ILIE**

***Abstract***

Archaeological research in the site of Păuca - Hungarian Church started in 2010, and between 2012-2023 has uncovered over 116 graves, some being simple cremation graves with a deposit of remains in the urn, others being double graves (with two urns) and one being a mixed double grave (incineration and inhumation). The dating of the five samples from the cemetery would suggest that the beginnings of the Păuca cemetery is contemporary with the late Germanic period (Gepids) and the early Avar period. Admitting that it is more accurate to date closer to the upper limit of the range (7th century), the cemetery at Păuca could be connected with historical events that occurred between 567 and 630, i.e. the establishment and consolidation of Avar power in the Pannonian-Transylvanian space. The $C^{14}$ dating of the cremated bones from the Păuca cemetery (Sibiu county) reopens the discussion on the need for more samples of $C^{14}$ data from the cremation cemeteries attributed cemetery to the so-called *Mediaș group* and simultaneously may represent a turning point in the evaluation of the chronology of the period between 6th and 8th centuries A.D.

**Keywords:** $C^{14}$ data, cremation cemetery, Romania, Mediaș Group, migration period

## Introduction

The village of Păuca is the centre of the commune of the same name and is located 50 km north-west of the city of Sibiu, on the border of Sibiu and Alba counties (fig. 1).

[1] A reduced form of this text was published in Romanian in *Argesis. Studii și Comunicări*, seria Istorie, tom XXIX (2020): 37-52.


**Fig. 1**. Păuca - location on Central and South East Europe map

The settlement was first documented during the reign of King Ladislaus IV (1272 - 1290), who donated the *Pokafolua* estate to the parish priest of Apoldu de Sus, Paulus and his brother Poka[2]. After Poka's death, the property was passed on to his descendants, so that in 1299 his possessions were mentioned and divided among his heirs, with the words *'Distinctio autem terre Keretnuk facta cum terra* ***filiorum Pouka*** *habente ecclesiam [...] presentibus ipsis filiis Luanka"*[3].

The earliest archaeological finding from the area dates back to 1884, when a bronze[4], Scythian mirror was found in an unspecified location. Over the years, both Eneolithic ceramic fragments belonging to the Coțofeni culture as well as Roman remains of what appeared to be a vicus (a rural settlement of the second and third centuries during the Roman period[5] have also been discovered by chance near the locality). On the north-western limit of the settlement, at the *Homm* point, a settlement belonging to the Petrești Eneolithic culture[6] was investigated during 1965 and 1966 by Iuliu Paul. Together with the archaeological discoveries, the ecclesiastical heritage of Păuca, containing three churches, is worth mentioning:

---

[2] Maria Crîngaci Tiplic, *Oaspeții germani in sudul Transilvaniei*, (Editura Academiei Romane: Bucuresti, 2011), 258.

[3] Jakó Zsigmond (ed.), *Erdélyi okmánytár : Oklevek, levelek ésmás írásos emlékek Erdélyi történetéhez* I. 1023 – 1300, Magyar Országos Levéltár kiadványai. 2. Forráskiadványok (26), (Akadémiai Kiadó: Budapest, 1997), 333

[4] Valentin Vasiliev, *Scitii agatirsi pe teritoriul Romaniei*, (Editura Dacia: *Cluj-Napoca, 1980)*, 113, 121, 130, 148, 181, 183.

[5] Dumitru Popa, *Viata rurală în Transilvania romană*, (Editura Alma Mater: Sibiu, 2001), 175, 191.

[6] Iuliu Paul, "In legătură cu problema locuințelor de suprafață cu platformă din așezările culturilor Petrești și Cucuteni-Tripolie". *SCIV*, 18 (1967): 3-24.

- the church located on one of the north-west hills and built, according to the historiography, in the 13th century, is dedicated to St. Mary; most probably initially built as a Romanesque basilica, with two towers on the western façade and later remodeled Gothic in the 15th century;

- from the Saxon church towards South-East, on the hill, there is another church, originally built in the Gothic style, which was initially part of a monastery complex of the Pauline Order[7] but later abandoned just to ultimately became the parish church of the Hungarian Calvinist community. The church functioned until the early 1990s, when it was abandoned once again and left in ruins. This area is the main focus of the present archaeological research;

- to the east of the Hungarian church, on a third hill, the Orthodox church, a brick construction dating from the late 18th century is placed.

* * *

Archaeological research in the site of the Păuca - *Hungarian Church* began in 2010, with the aim of clarifying its belonging to a monastery complex owned by the order of St. Paul of Thebes (Paulin)[8]. In the archaeological unit at the Northern side of the church, in front of the Renaissance portal, a cremation urn (U1), decorated with bands of straight and wavy lines, belonging to a cremation cemetery was discovered (fig. 2).

**Fig. 2.** Păuca - S13: location of U1

7 Beatrix Romhány, "New results on the Medicant Economy in Medieval Hungary: Spatial Distribution, Urban (?) Context". *Studia Universitatis Babeş-Bolyai. Historia*, 60 no. 1 (2015): 15-38; Corina Hopârtean, "Ordinul Sfântului Paul Eremitul, în interiorul granițelor Regatului maghiar". *Transilvania*, 3-4 (2015): 66-72; Corina Hopârtean, "Despre ordinul Paulin în textele scrise (secolele XV-XVI)". *Alt-Schaessburg*, 10 (2017): 71-80.

8 Corina Hopârtean, "Ordinul Sfântului Paul Eremitul...", 66-72.

This discovery came as a surprise considering that there was no information about the existence of a cremation cemetery in the area of Păuca village. Thus, as a result of archaeological research conducted between 2012-2023, 116 cremation graves were discovered in the cemetery of Păuca (fig. 3), some of them being simple cremation graves with the deposition of remains in urns, others being double or multiple graves (with two or more urns) and one mixed double grave (cremation and burial) (fig. 4).

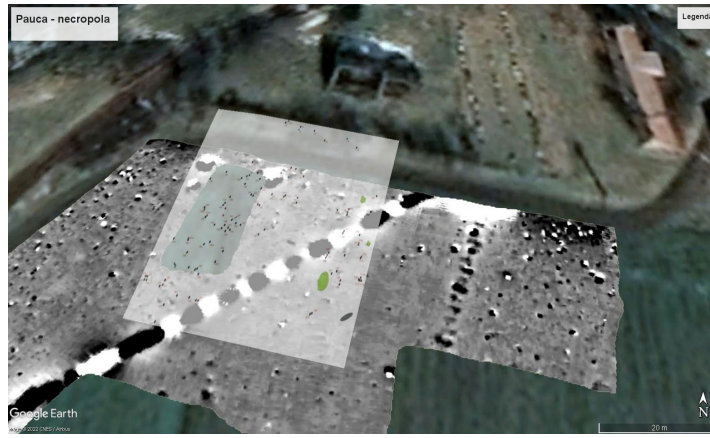


**Fig. 3.** Păuca - Geophysical survey (by Alexandru Popa) with cemetery plan overlay


**Fig. 4.** Păuca - multiple graves (U103-U106) and double grave (inhumation and cremation)

All the research effort - to date and in the future- channeled towards analysis, interpretation, conservation, restoration, museum and scientific valorization, would not have been and will not be possible without the involvement of all

the members of the research team composed of CȘ I Dr. Maria Emilia Țiplic (Institute for Socio-Human Research in Sibiu), Dr. George Tomegea (National Museum Complex "Astra"), Dr. Adrian Șovrea (University "Lucian Blaga" of Sibiu), together with various students from the Department of History, Heritage and Protestant Theology of the University "Lucian Blaga" of Sibiu.

The tombs investigated so far have been discovered at quite shallow depths, between -0.40m and -0.80m, factor that has led to the destruction of the urns due to agricultural works carried out over the years. Most of the urns have been found in a fragmentary state, with many of the vessels missing the lip or other parts of the vessel body. Unfortunately, the nature of the soil does not allow the pits to be analyzed, but it is strongly believed that they were circular or ovoid, as in other similar cemeteries. The urns were deposited upright but later tilted in different directions under the weight of the earth. They had no lids and their contents consisted of earth, charred bones, charcoal,, and ashes. In some of the cases, several pieces of charcoal or even charred bones were also observed outside the urns.

The most numerous archaeological material consists of ceramic vessels in which the cremated remains of the deceased were deposited. The urns were made by slow wheel-working, using a finer or coarser paste, the clay being mixed with fine or coarser-grained sand. Apart from the pottery, very few other inventory items were found inside the urns), namely: a leaf-shaped arrowhead, an iron ring, a buckle pin, an iron fragment (possibly from a fire steel) and an S-shaped earring (to be the subject of another study). In general, the cemeteries in this horizon are characterized by a small number of funerary inventory objects, although a series of ornaments even made of gold and silver are known to have been discovered in some cemeteries in Transylvania[9].

Given the very close resemblance of the urns with others from similar cemeteries, the cemetery at Păuca is considered a part of what Kurt Horedt called the *Mediaș group*[10] (see fig. 5), whose reconstructed chronology model, proposed since the late 1960', is limited to the 7th-9th centuries A.D.

---

[9] George Tomegea, "Accesorii vestimentare și podoabe în necropolele birituale din Transilvania (sec. VII-IX)". *Analelel Banatului*, S.N. Arheologie-Istorie, XIX (2011): 209-220.

[10] Kurt Horedt, "Un cimitir din sec. IX-X e. n. la Mediaș". *Studia Universitatis Babeș-Bolyai*, serie Historia, II (1965): 7-25; Kurt Horedt, "Die Brandgräberfelder der Mediaşgruppe aus dem 7.-9. Jh. in Siebenbürgen". *Zeitschrift für Archäologie* 10 (1976): 35-57; Kurt Horedt, "Die Brandgräberfelder der Mediaşgruppe aus dem 7.-9. Jh. in Siebenbürgen". *Rapports du IIIe Congrès International d'Archèologie Slave*, tom I, Bratislava (1979): 385-393; Ioan Marian Țiplic, "Necropolele de tip Mediaș din Transilvania". *Acta Musei Napocensis,* 39-40, no. II (2002-2003): 9-24; George Tomegea, "The analysis of the cremation graves of the biritual necropolises of Transylvania (7th and 9th centuries)". *Brukenthal. Acta Musei*, VII, no. 1 (2012): 101-115; Ioan Marian Țiplic, George Tomegea, *Păuca. Necropola de incinerație (secolele VIII-IX). Catalog de expoziție*, (Editura Astra Museum: Sibiu, 2017).

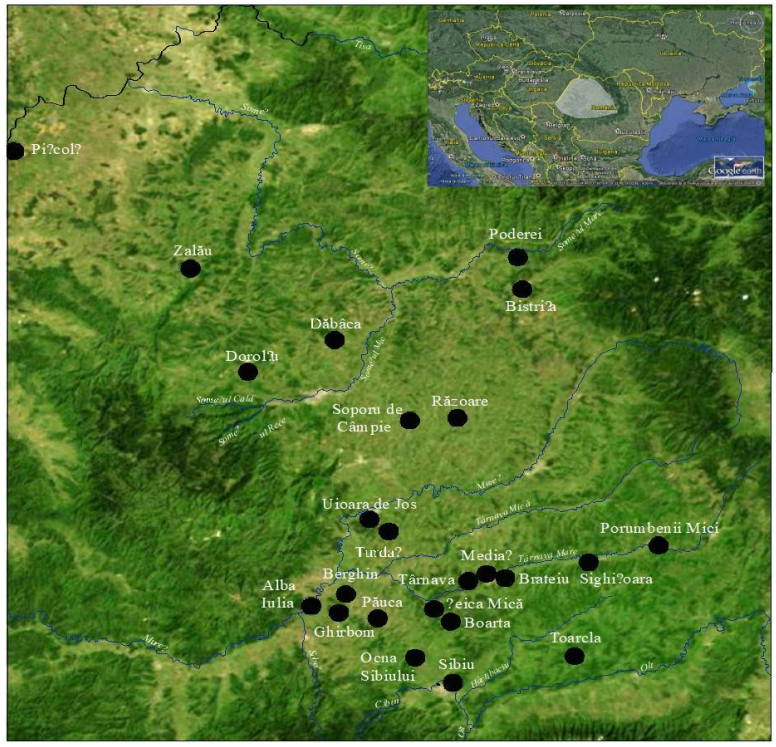


**Fig. 5.** The cremation cemeteries belonging to the so-called type Mediaș in Transylvania.

***

The history of Transylvania during the 7th to 9th century period is quite controversial, given the fact that the process of ethno-genesis is considered to have happened during the aforementioned period. Both the low number of systematic archaeological research and the lack of publication of the results contribute to the poor knowledge about this period, yet these are considered typical problems of Romanian archaeology.

For the history of Central and South-Eastern Europe in the second half of the 1st millennium AD, archaeological research on burial sites plays a special role, representing the largest percentage of sites investigated to date. Transylvania as both a geographical and cultural-historical area was and continues to be almost organically connected to Central Europe[11]. However, it has often been a territory of convergence of cultural and political influences coming from the western part of the continent, as well as from the Southern Danube areas or the Northern Pontic steppes.

[11] Ioan Marian Țiplic, Maria Emilia Țiplic, "The Christianization of the Funeral Rite in the Early Middle Ages". *Transylvania Review*, XXIV, no. 2 (2015): 264-278; Ioan Marian Țiplic, "Theoretical premises of christening of funeral rite in early Middle Age". *Acta Terrae Septemcastrensis*, XXI (2022): 83-105; Ioan Marian Țiplic, "De la incinerație la inhumație în spațiul transilvan. Un fenomen care marchează creștinarea ritualului funerar la sfârșitul secolului al X-lea?" *Varia Archeologica. III: Situri și peisaje arheologice din spațiul românesc*, (Editura Mega: Cluj-Napoca, 2023): 317-332.

One of the elements which, from this perspective, have identified the Transylvanian space is represented by the horizon of the burial and/or burial cemeteries, which came to the attention of Romanian archaeologists especially from 1950 to 1970 when political pressure led to the development of lines of research on the ethnogenesis of the populations of the Southern and Northern Danube areas from the perspective of the role played by Slavic migration. The subject was, to a certain extent, abandoned in the 1980s and 2000s, being revived in Romanian historiography with the appearance of the work *Apariția slavilor. Istorie și arheologie la Dunărea de Jos în veacurile VI-VII* (the first edition was published in English under the title *The Making of the Slavs*) by Florin Curta[12].

The cemeteries attributed to the *Mediaș group* are part of the first burial sites investigated by systematic archaeological excavations starting in Mediaș (1969) and continuing with subsequent research in similar cemeteries at Sibiu-Guștereița, Bratei, Dăbâca, Boarta, Târnava, Berghin and more recently, Păuca (see Tabel A).

| Nr.crt. | Localizare | Datare | Morminte de incinerație | Morminte de inhumație |
|---|---|---|---|---|
| 1 | Alba Iulia Stația de salvare | VIII-IX | 4 | 0 |
| 2 | Berghin În Peri | VII-IX | 360 | 0 |
| 3 | Bistrița | ? | 2 | 0 |
| 4 | Bratei Cimitirul 2 | VII-VIII | 210 | 34 |
| 5 | Boarta Șoivani | VIII-IX | 33 | 2 |
| 6 | Dăbâca | VIII-IX | 16 | 0 |
| 7 | Dorolțu Dâmbu Mic | VI-VII | 2 | 0 |
| 8 | Ghirbom Gruiul Fierului | IX-X | 11 | 9 |
| 9 | Mediaș | VII-VIII (IX) | 14 | 3 |
| 10 | Păuca (2022) | VII-VIII | 106 | 1 |
| 11 | Pișcolț Nisipărie | VII | 7 | 0 |
| 12 | Porumbenii Mici Galath | VII-VIII | ? | ? |
| 13 | Ocna Sibiului Lab | VIII-IX | 120 | 15 |
| 14 | Sibiu - Guștereița Fântâna Rece | VIII-IX | 79 | 1 |
| 15 | Sighișoara | VI-VIII | 13 | 1 |
| 16 | Soporu de Câmpie Poderei și Sânișoara | IX și VIII-IX | 13(14) | 2 |
| 17 | Șeica Mică | ? | 1 | 0 |
| 18 | Târnava | VIII-IX | 31 | 5 |
| 19 | Toarcla | VIII-IX | 1 | 0 |
| 20 | Turdaș (jud. Alba) | VIII | 18 | 0 |
| 21 | Uioara de Jos | VIII-IX | 42 | 0 |
| | | | | |
| | | **TOTAL** | **1083(1084)?** | **73?** |

**Tabel A.** List of Mediaș type cemeteries in Transylvania and the number of graves

[12] Florin Curta, The Making of the Slavs: History and Archaeology of the Lower Danube Region, c.500-700, (Cambridge University Press, 2001); Florin Curta, Apariția slavilor. Istorie și arheologie la Dunărea de Jos în veacurile VI-VII, (Editura Cetatea de Scaun: Târgoviște, 2006).

These cemeteries are part of a horizon of cremation cemeteries placed chronologically in the interval between the 7th and 10th centuries, in a geographical area that includes Central Europe (see Fig. 6) and the Northern and Southern Lower Danube areas. The chronology of this horizon is based on comparative analysis and the typological series carried out mainly during the 1970s and 1990s, without the use of a chart based on $C^{14}$ dating for any of the cemeteries. This method, based in particular on funerary pottery typology, has led to the broad chronological placement of the horizon between the 7th-9th/10th centuries.

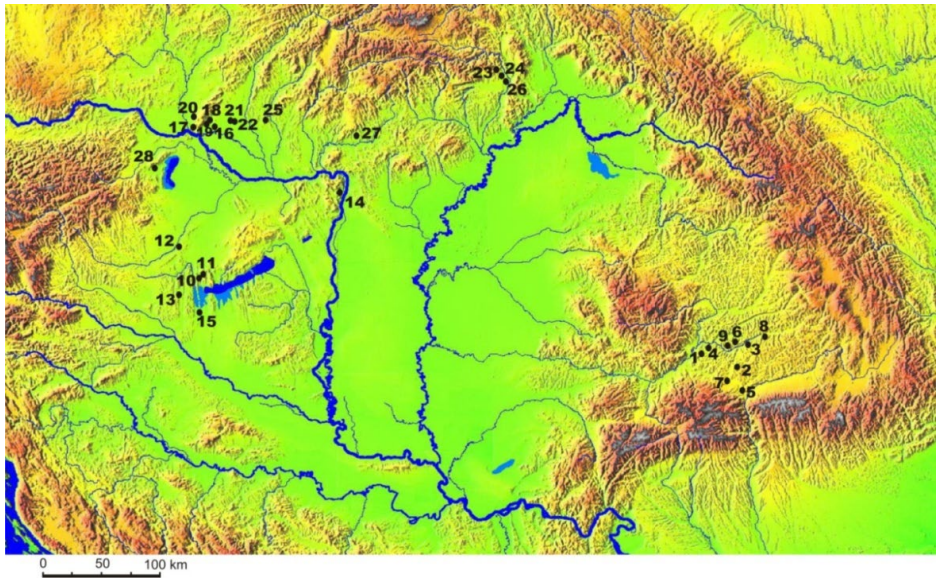


**Fig. 6.** Distribution of cremation cemeteries in the Carpathian Basin (after G. Tomegea, PhD Thesis)

With all the limitations that come with the impossibility to extract collagen from charred bones and in an attempt to place the funerary horizon in the absolute chronology of Central Europe, it is significant to observe what dating can be obtained through $C^{14}$ radiocarbon dating. For this reason, the collaboration of ULBS with IFIN-HH is one that begins a pioneering action in Romanian archaeological research that, through the obtained results can provide a chronological diagram that will allow greater accuracy in the dating of the cremation cemeteries belonging to the *Mediaș group*.

The dating of bones from cremation graves is a method developed in the late 1990s (Lanting t al. 2001, 249-54), that has already generated a number of debates on the absolute chronological corrections that should be made for the post-Roman and early medieval period due to some inconsistencies between the relative dating used and the $C^{14}$ dating results.

In the case of the cremation cemetery at Păuca, 5 graves were selected in the first step of C14 dating process (see Fig.7):

**U2**: burial urn discovered in S6/ 2013

Dimensions: H: 20.6 cm; DF: 9.4 cm; D max.: 20.8 cm

Description: domed body pot, with very thick walls, flared lip and straight cut. Worked on a slow wheel; the paste used contains medium grain sand as degreaser. The decoration starts from the shoulder with a band of straight lines, followed by two bands of wavy lines and another band of straight lines. The vessel is unevenly burned and grey in color. Significant pieces are missing from the top.

**U6**: funerary urn discovered in S12/ 2014

Dimensions: H: 22 cm; DG: 15.5 cm; DF: 9.8 cm; D max.: 21.2 cm

Description: slender pot of scarlet and grey (upper side) coloration. Decorated with horizontal lines over most of its surface. The lip is missing. The pot is worked on a slow wheel, with oxidative firing. The bottom is slightly recessed inwards. The clay has been mixed with fine sand.

**U8**: funerary urn discovered in S12/ 2014

Dimensions: H: 26.4 cm; DG: 18.2 cm; DF: 8.7 cm; D max.: 24 cm

Description: slender pot, with a very pronounced neck, and flared opening and straight cut lip. Wheel-worked from a homogeneous paste mixed with small pebbles and sand degreaser. The decoration, consisting of parallel horizontal lines, extends from the neck down, covering almost the entire surface of the pot. The firing is oxide-reducing, resulting in a scarlet color with grey spots on the area of the maximum diameter. Parts of the lip are missing.

**U10**: funerary urn discovered in S14/ 2014

Dimensions: H: 14 cm; DG: 7 cm; DF: 6.3 cm

Description: flared mouth pot, with a lip turned slightly towards the body. The urn is wheel-worked from homogeneous paste mixed with fine sand. It is ornamented on two thirds of the body surface; the decoration begins below the neck and consists of bands of two lines each forming the motif of the eye. The vessel is uniformly burnt and is scarlet in color.

**U18**: funerary urn discovered in S19/ 2015

Dimensions: H: 20,4 cm; DF: 9,8 cm; D max.: 23,3

Description: ovoid pot of which only the lower part (up to the area of maxim diameter) is preserved. The vessel has been wheel-worked from a coarse paste mixed with large-grained sand. Decorated on the upper part with horizontal parallel lines. The firing was uneven, thus the vessel is light grey in color, with patches of scarlet.


**Fig. 7.** Păuca - urns after restoration

Sampling of the urns was carried out in the ceramic restoration laboratory of the CNM Astra Sibiu and consisted in collecting the soil, charred bones and charcoal from inside the urns belonging to the mentioned tombs. The contents of the urns selected for $C^{14}$ dating were transferred to IFIN-HH.

## Radiocarbon dating of cremated bone samples

The rites of passage through life (birth, marriage, burial - assimilated through the counterpart notions from our current thinking) have varied with the evolution of human society. So have the "traces" left by them over time. Of all of them, the burial ritual is most related to the types of analyses that can be applied to the osteological material that survived the moment. Basically, we will be referring to cases where the deceased has been deliberately subjected to a cognitive, "artificial"

process, beyond situations where the body naturally enters the post-depositional phase by the time of excavation, and which represent the majority of cases over a good segment of the history of the existence of the human race, but no older than 65,000 years - the lower limit of AMS radiocarbon dating by the Libby Half-life of carbon-14, $T_{1/2}$ = 5568 years[13].

In terms of archaeological material recovered from excavations, the discoveries from Romania are, in most cases, relatively rather well preserved or poorly preserved due to the specific climate of our country that is not very favorable for the preservation of the archaeological context. This is obviously true primarily for the organic support material. Bones, in particular, are a mixture of "inorganic" and "organic", as opposed to wood, fabrics, food, etc. That is why the inorganic component is preserved first, to the detriment of the organic one – which is the most sought after component in archaeometry, especially in ancient DNA analysis and radiocarbon dating.

The fact that for a long time burial rites consisted of burning/incineration/cremation of bodies presents two important yet contradictory traits: on one hand it preserves much better the inorganic structure of the osteological material due to the use of heat treatments, on the other hand it almost completely destroys the organic component, considered the most reliable in radiocarbon dating.

However, this archaeometric technique of absolute dating has a clear advantage over ancient DNA analysis; in the latter case, the long period during which heat treatments were used on corpses becomes 'forbidden territory' for obtaining certain data.

Radiocarbon dating is also not free from "pitfalls", the most important being the "Hallstatt-plateau" where carbon dioxide fluctuations in the earth's atmosphere do not allow a reliable interdependence of the $C^{14}$ decay curve on the time variable. Thus, for the approximate representation of the range, for a reasonable combined standard measurement of uncertainty distribution corresponding to at most ± 20 years BP, the range of values will extend to a range several times larger, which reduces the AMS measurement performance efforts of single samples to "modest" sizes, according to the latest integrations of the radiocarbon calibration curve, IntCal 20 (see Fig. 8) provided online by the Oxford Radiocarbon Unit, UK[14].

---

[13] Nicolae Stoia, *Datări de ordinul $10^2$ ani prin metoda $^{14}C$*, Lucrare absolvire CUIR (1970): 401-419; László Attila, *Datarea prin radiocarbon în arheologie*, Muzeul Național de Istorie a României, Biblioteca Muzeului Național II, (București, 1997).

[14] Paula J. Reimer, Edouard Bard, Alex Bayliss, J. Warren Beck, Paul G. Blackwell, Christopher Bronk Ramsey, Caitlin E. Buck, Hai Cheng, R. Lawrence Edwards, Michael Friedrich, Pieter M. Grootes, Thomas P. Guilderson, Haflidi Haflidason, Irka Hajdas, Christine Hatté, Timothy J. Heaton, Dirk L. Hoffmann, Alan G. Hogg, Konrad A. Hughen, K. Felix Kaiser, Bernd Kromer, Sturt W. Manning, Mu Niu, Ron W. Reimer, David A. Richards, E. Marian Scott, John R. Southon, Richard A. Staff, Christian S. M. Turney, Johannes van der Plicht, "IntCal13 and Marine13 Radiocarbon Age Calibration Curves 0–50,000 Years cal BP". *Radiocarbon*, 55, no. 4 (2013): 1869-1887.

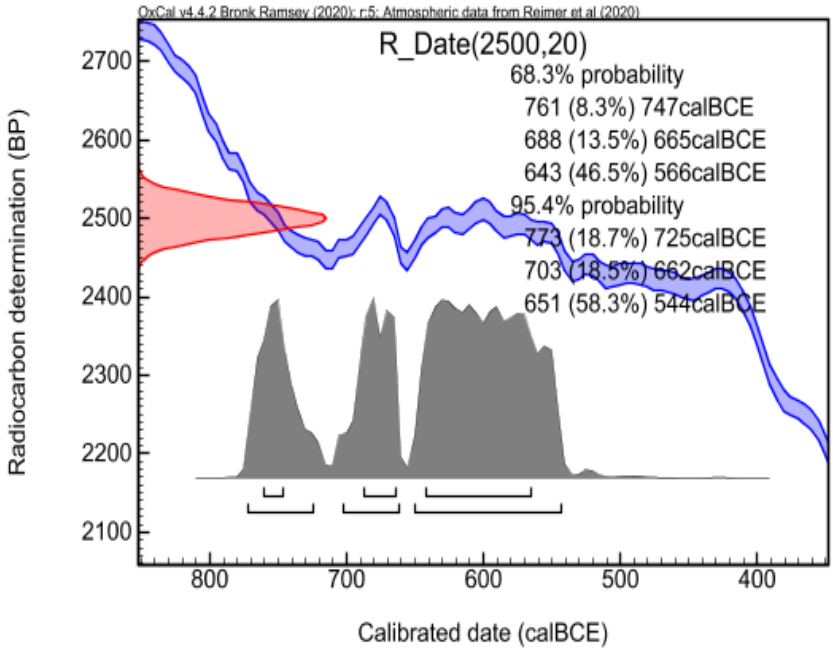


**Fig. 8** „Hallstatt plateau" in carbon dating.

In other words, the possibility of restricting the results obtained to a representative and meaningful interval often "throws" them into several sub-stage "buckets" that are different from each other in terms of relative or contact chronology, thus significantly diminishing the relevance of the method itself for archaeologists.

At the other "end" of the significance of absolute dating is the "Stradivarius threshold" (after the second half of the 17th century to the mid-20th century), which imposes a limitation on the performance of the radiocarbon method, mainly due to the impact of human activities, most notably the industrial revolution (Jull 1997) and not due to the conditions of natural evolution of atmospheric carbon dioxide concentration. In fact, these, together with the onset of the nuclear age after the second half of the 20th century, led to the "final threshold" of the radiocarbon method being reached, from a historical and archaeological viewpoint. After 1950, the "rules of the game" were completely rewritten by calibration curves taking into account the "Bomb Pulse Effect"[15].

[15] Dai Kaimei, Qian Youneng, C. V. Fan, "Bomb-Produced 14C in Tree Rings". *Radiocarbon*, 34, no. 3 (1992): 753-756; Mebus A. Geyh, "Bomb Radiocarbon Dating Of Animal Tissues And Hair". *Radiocarbon*, 43, no. 2B (2001): 723–730. Proceedings of the 17th International 14C Conference, edited by I. Carmi and E. Boaretto; Quan Hua, Mike Barbetti, "Review of tropospheric bomb 14C data for carbon cycle modeling and age calibration purposes". *Radiocarbon*, 46, no. 3 (2004): 1273–1298; Paula J. Reimer, Thomas A. Brown, Ron W. Reimer, "Discussion: Reporting and Calibration of Post-Bomb 14C Data". *Radiocarbon*, 46, no. 3 (2004): 1299–1304.

We could consider that the range ca. 450 BCE - 1650 CE would be conducive to such determinations, helping to refine conclusions from relative chronology (where it can be established) or to provide information where there is no archaeological context. This is mostly true due to the continuous improvement of AMS techniques, but there are some limitations in achieving high-performance results due to the specific characteristics of the calibration curve over short or very short time intervals for the 5th-6th, 8th, 10th, partly the 11th, 14th centuries, whereas the data for the 7th, 9th, 13th, 15th, 17th centuries are more "high-performance" in terms of radiocarbon data. In contrast, the 12th, 14th, 16th and 18th centuries, for reasons also related to the production of cosmogenic $C^{14}$ (Little Ice Age, ca. 1300-1870) or to anomalies determined by particular cosmic phenomena (produced on several occasions, as shown in Table B below), also become "deficient"[16].

| **Moments of Earth contact with cosmic „Superwave" phenomena (Original prediction, in AD/CE or BC/CE years)** | **Energy events from the geological record, expressed in calendar years AD/EC or BC/ECB, determined by various techniques** |
|---|---|
| 1289 ± 104 AD | 1250 – 1350 AD (Dome Fuji Be-10)<br>1265 – 1267 AD (GISP 2 ECM) |
| 1020 ± 144 AD | 1017 ± 10 AD (Dome Fuji Be-10) |
| 993 ± 148 AD | 993 – 994 AD (tree rings C-14)<br>1000 ± 10 AD (Dome Fuji Be-10) |
| 943 ± 155 AD | 900 ± 10 AD (Dome Fuji Be-10)<br>950 AD (GISP 2 ECM) |
| 828 ± 173 AD | 800 ± 10 AD (Dome Fuji Be-10) |
| 746 ± 185 AD | 774 – 775 AD (tree rings C-14)<br>754 & 761 AD (GISP 2 ECM) |
| 651 ± 199 AD | 695 AD (GISP 2 ECM) |
| 253 ± 259 AD | |
| 6 ± 296 AD | |
| 487 ± 370 BC | |
| 610 ± 388 BC | |
| 1042 ± 453 BC | |
| 3200 ± 777 BC | 3230 - 3330 BC (tree rings C-14)<br>3266 BC (GRIP NO-3 peak)<br>3320 – 3335 BC (GISP 2 haitus)<br>3250 BC (Quelccaya Cap blizzard) |

**Table B.** Radiocarbon anomalies influencing the calibration curve for the medieval period.

Although they affect the territory of Romania to a lesser extent than the Mediterranean Sea basin, other anomalies must also be taken into account when

[16] Juan Antonio Quirós Castillo, "Las dataciones radiocarbónicas de yacimientos deépoca histórica. Problemas y experiencias de análisisen contextos de época medieval". *MUNIBE (Antropologia-Arkeologia),* 60 (2009): 313-324; Paul LaViolette, *Independent Confirmation of the Arrival of 8 Minor Superwave Events in the past 1300 years,* 25 August 2013; Accesed on June 1st 2015.

estimating the chances of success of a sustainable and high quality radiocarbon dating, beyond reaching the highest level of performance of the physical and chemical methods involved at the time of analysis[17].

## Absolute chronology data obtained for the Păuca - Hungarian Church site

Regarding the expectations for the 5 selected cremated bone samples from the Păuca - Hungarian Church site, in conformity with the information previously presented by the archaeologist, the estimates were convergent towards dating them in the 7th-9th centuries CE, a period corresponding to the Middle Ages, i.e. in the wide range of 600-900 CE.

By the criterion of the chances of obtaining a reliable radiocarbon result and on a narrow range, as observed above in the archaeometry section, the risks ranges would include 8th century intervals, more precisely precise dating around the years: 695, 754, 761, 774-775, 800, 900.

Physicochemical processing of the bone samples, with destruction of exogenous and endogenous organic carbon, subsequent graphitization of trapped carbon dioxide in the inorganic matrix at the CHS - AGE 3 system (IonPlus, CH) and obtaining radiocarbon data at the 1 MV Walton Crockcroft Tandetron accelerator (HVEE, NL) provided the following intervals at the RoAMS Laboratory at IFIN-HH[18] (see Table C and Fig.10).

[17] Johannes van der Plicht, Hendrik J. Bruins, Albert J. Nijboer, "The Iron Age Around the Mediterranean: A High Chronology Perspective from the Groningen Radiocarbon Database". *Radiocarbon*, 51, no. 1 (2009): 213-242; Bernd Kromer, Sturt W. Manning, Michael Friedrich, Sahra Talamo, Nicole Trano, "$^{14}$C calibration in the 2nd and 1st Millennia BC-Eastern Mediterranean radiocarbon comparison project (EMRCP)". *Radiocarbon*, 52, no. 2-3 (2010): 875-886 (*Proceedings of the 20th International Radiocarbon Conference*, edited by A.J.T. Jull); Douglas J. Keenan, "Why early-historical radiocarbon dates downwind from the Mediterranean are too early". *adioRcarbon*, 44, no. 1 (2002): 225-237; Malcolm H. Wiener, "Problems in the measurement, calibration, analysis, and communication of radiocarbon dates (with special reference to the Prehistory of the Aegean world)". *Radiocarbon*, 54, no. 3-4 (2012): 423-434 (*Proceedings of the 6th International Radiocarbon and Archaeology Symposiu*m, edited by E. Boaretto and N.R. Rebollo Franco).

[18] R.E.M. Hedges, G.J. Van Klinken, "A review of current approaches in the pretreatment of bone for radiocarbon dating by AMS". *Radiocarbon*, 34, no. 3 (1992): 279-291; Richard Gillespie, "Burnt and unburnt carbon: dating charcoal and burnt bone from the Willandra Lakes, Australia". *Radiocarbon*, 39, no. 3 (1997): 239-250; JN Lanting, AT Aerts-Bijma, J.van der Plicht, "Dating of cremated bones". *Radiocarbon,* 43(2A) (2001): 249-254; Christopher Bronk Ramsey, Thomas Higham, Angela Bowles, Robert Hedges, "Improvements to the pretreatment of bone at Oxford". *Radiocarbon*, 46, no. 1 (2004): 155-163; Philip Naysmith, E. Marian Scott, Gordon T. Cook, Jan Heinemeier, Johannes van der Plicht, Mark Van Strydonck, Christopher Bronk Ramsey, Pieter M Grootes, Stewart P.H.T. Freeman, "A cremated bone intercomparison study". *Radiocarbon*, 49, no. 2, (2007): 403-408; Mark Van Strydonck, Mathieu Boudin, Guy De Mulder, "14C dating of cremated bones: the issue of sample contamination". *Radiocarbon*, 51, no. 2 (2009): 553-568; Guy De Mulder, Mark Van Strydonck, Mathieu Boudin, "The impact of cremated bone dating on the archaeological chronology of the Low Countries". *Radiocarbon*, 51, no. 2 (2009): 579-600; A. Zaz-

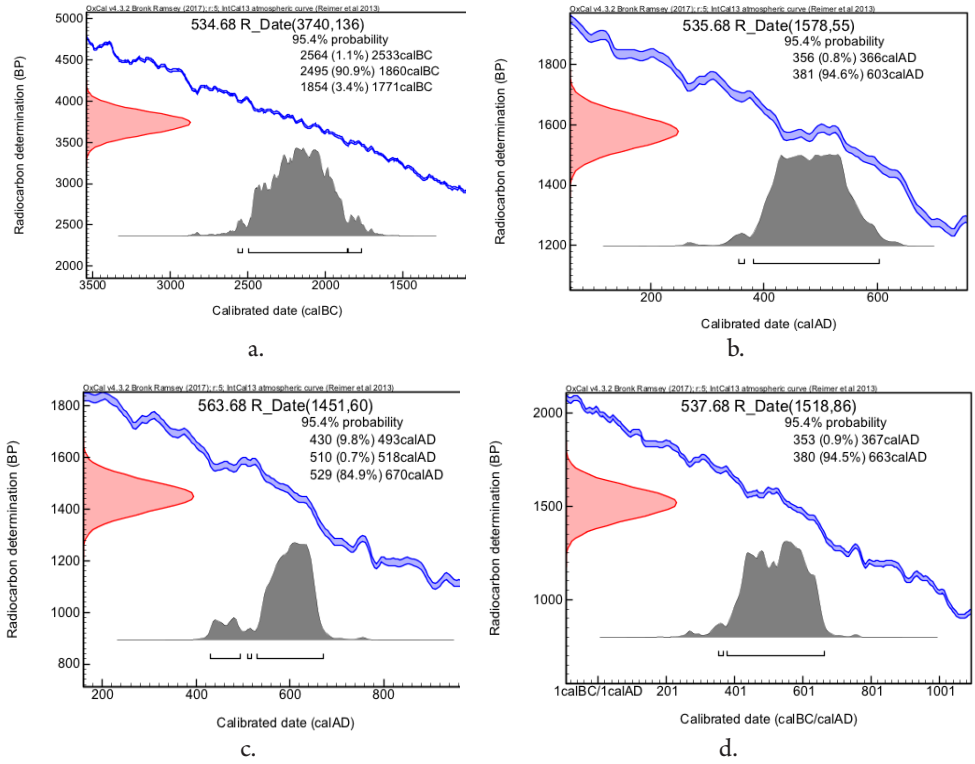


**Fig.9.** Păuca - calibration curves:a. U6; b. U8; c. U10; d. U18

zo, J-F. Saliège, A. Person, H. Boucher, "Radiocarbon dating of calcined bones: where does the carbon come from?". *Radiocarbon*, 51, no. 2 (2009): 601-611; C.M. Hüls, H. Erlenkeuser, M-J. Nadeau, P.M. Grootes, N. Andersen, "Experimental study on the origin of cremated bone apatite carbon". *Radiocarbon*, 52, no. 2-3 (2010): 587-599 (Proceedings of the 20th International Radiocarbon Conference, edited by A.J.T. Jull); Jesper Olsen, Karen Margrethe Hornstrup, Jan Heinemeier, Pia Bennike, Henrik Thrane, "Chronology of the Danish Bronze Age based on 14C dating of cremated bone remains". *Radiocarbon*, 53, no. 2 (2011): 261-275; Guy De Mulder, Mark Van Strydonck, Rica Annaert, Mathieu Boudin, "A Merovingian surprise: early medieval radiocarbon dates on cremated bone (Borsbeek, Belgium)". *Radiocarbon*, 54, no. 3-4 (2012): 581-588 (Proceedings of the 6th International Radiocarbon and Archaeology Symposium, edited by E. Boaretto and N.R. Rebollo Franco); Antoine Zazzo, Jean-François Saliège, Matthieu Lebon, Sébastien Lepetz, Christophe Moreau, "Radiocarbon dating of calcined bones: insights from combustion experiments under natural conditions". *Radiocarbon*, 54, no. 3-4 (2012): 855-866 (Proceedings of the 6th International Radiocarbon and Archaeology Symposium, edited by E. Boaretto and N.R. Rebollo Franco); Antoine Zazzo, Matthieu Lebon, Laurent Chiotti, Clothilde Comby, Emmanuelle Delqué-Kolië, Roland Nespoulet, Ina Reiche, "Can we use calcined bones for 14C dating the Paleolithic?". *Radiocarbon*, 55, no. 2-3 (2013): 1409-1421 (Proceedings of the 21st International Radiocarbon Conference edited by A.J.T. Jull & C. Hatté); C. Snoeck, F. Brock, R.J. Schulting, "Carbon exchanges between bone apatite and fuels during cremation: impact on radiocarbon dates". *Radiocarbon*, 56, no. 2 (2014): 591-602; L. Wacker, M. Christ, H.-A. Synal, *Bats: A new tool for AMS data reduction. Nuclear Instruments & Methods in Physics Research Section B-Beam Interactions with Materials and Atoms*, 268 (2010): 976-979; L. Wacker, R.-H. Fulop, I. Hajdas, M. Molnar, J. Rethemeyer, "A novel approach to process carbonate samples for radiocarbon measurements with helium carrier gas". *Nuclear Instruments and Methods in Physics Research B-Beam Interactions with Materials and Atoms*, 294 (2013): 214-217.

| Archaeologist code | Laboratory code | Intervals and sub-intervals for □ |
|---|---|---|
| „Păuca – Hungarian Church U6" | 534.68 | *2564 (1.1%)2533 calBCE*<br>*2495 (90.9%) 1860 calBCE*<br>*1854 (3.4%)1771 calBCE* |
| „Păuca – Hungarian Church U8" | 535.68 | *cal CE 356 (0.8%)366*<br>*cal CE 381(94.6%) 603* |
| „Păuca – Hungarian Church U10" | 536.68 | *cal CE 430 (9.8%) 493*<br>*cal CE 510 (0.7%) 518*<br>*cal CE 529 (84.9%) 670* |
| „Păuca – Hungarian Church U18" | 537.68 | *cal CE 353 (0.9%)367*<br>*cal CE 380 (94.5%) 663* |

**Table C.** Calibrated radiocarbon data obtained for the cremated bone samples excavated from the Păuca - Hungarian Church site, Sibiu County

The sample "Păuca - Hungarian Church U2" (code 533.68) did not provide datable material. Apart from sample 534.68 (U6) which clearly belongs to an otherwise reliable radiocarbon dating horizon of the Eneolithic period, reported near the archaeological site under investigation, the other three calibrated dates are all outside the segments of the calibration curve that raise problems. However, the results are partly contained in centuries with a poorer performance regarding the sub-intervals component for the 5th and 6th centuries.

Therefore, if the laboratory processing and measurements are correct, the deaths and cremations occurred somewhere between the 4th and 7th centuries CE, representing an earlier time horizon and cultural phase than the archaeologist's initial expectations.

The technical arguments underlying the reliability of the results obtained by absolute chronology are:

1. The combination of radiocarbon data through the OxCal program (see Fig.10 and Table D):

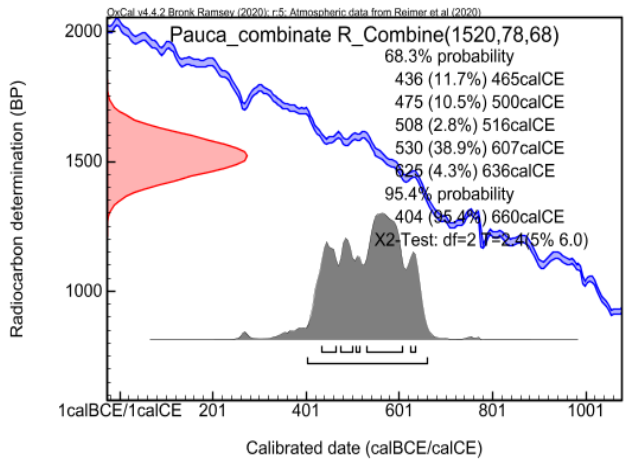


**Fig. 10.** Combining radiocarbon data for samples 535.68 - 537.68

| Show all<br>Show structure | | Unmodelled (BCE/CE) | | | | | | Select | Page break |
|---|---|---|---|---|---|---|---|---|---|
| | | from | to | % | from | to | % | All<br>Visible | |
| R_Combine Păuca_combinate | | 436 | 636 | 68.3 | 404 | 660 | 95.4 | ☑ ☑ 2 | ☐ |

**Table D.** Convergence of combination criteria using OxCal R_Combine function; IntCal 2020

The result given by combining the single values confirms the accuracy of the results obtained for each sample and shows that the three values belong to a very close/contemporaneous time horizon. Secondly it improves the representation statistics on the calibrated curve by restricting the intervals to the first half of the 5th century up until the first half of the 7th century. Even more precisely, for the most restrictive interval given by σ = 1, with probability of 68.3%, to calCE 530 (38.9%) 607. In principle, beyond the less favorable characteristics of the calibration curve that "throws" the results "all over the place" for the 6th century, in our case, the value is considered "modest" for current dating performances, especially due to the fact that the measurements were given from an inorganic substrate that trapped endogenous carbon dioxide, and not from collagen, formed during the lifetime of the individual. Last but not least, it is very unlikely to be wrong in every case analyzed in the same manner. The quality of the RoAMS results is reinforced by the inclusion of RoAMS on the Radiocarbon laboratories page, and by the publication of scientific articles in refereed international journals[19].

## Integration of archaeometric results and interpretation of radiocarbon data.

$C^{14}$ dating has resulted in a lowering of the lower limits of the chronological intervals for the European continent and for most pre- and proto-historic periods compared to the known relative chronology based on type-chronological analysis. The analysis of the evidence from the five cremation graves at Păuca (with two exceptions) is part of this trend.

If for U2 the situation is clear - dating cannot be made - the situation for U6 (534.68), which is typologically a typical urn for the horizon of cremation cemetries belonging to the *Mediaș group*, is rather strange, because the $C^{14}$ dating indicates a

[19] https://radiocarbon.webhost.uits.arizona.edu/node/11; C. Stan-Sion, M. Enăchescu, A.R. Petre, C.A. Simion, C.I. Calinescu, D.G. Ghita, "A new and compact system at the AMS laboratory in Bucharest". *Nuclear Instruments & Methods in Physics Research Section B-Beam Interactions with Materials and Atoms*, 361 (2015): 105-109; Tiberiu B. Sava, Corina A. Simion, Oana Gâza, Iuliana M. Stanciu, Doru G. Păceșilă, Gabriela O. Sava, Lukas Wacker, Bianca Ștefan, Vasile D. Moșu, Dan G. Ghiță, Alexandru Vasiliu, "Status Report on the Sample Preparation Laboratory for Radiocarbon Dating at the New Bucharest RoAMS Center". *Radiocarbon*, 61, no. 2 (2019): 649 – 648.

much earlier period (Eneolithic). This can be explained by the contamination of the sample, which could be explained by the discovery of sporadic Eneolithic and Bronze Age ceramic materials all over the surface of the cremation cemetery. The contamination could have occurred at the same time as the cremation ceremony, at a later moment or a much later time than the funeral ceremony. Given that the entire cemetery area was intensively used for agricultural activities and that most of the urns were 'touched' by the plough iron and destroyed or even scattered, it is not excluded that organic material/charcoal belonging to an Eneolithic complex may have ended up in the urn.

As for the results for the other three samples (535.68, 536.68, 537.68), they raise some questions about the chronology of the migration period because the lower and upper limits that are set are somewhat outside the accepted chronological range for the existence of cremation cemeteries. Also they initiate new discussions on the origin of the communities responsible for the appearance of these cremation cemeteries. At present we attribute these cemeteries to a chronological interval placed broadly between the 6$^{th}$ and 9$^{th}$ centuries and we correlate them with the presence of Slavic communities. The dating of the three samples would suggest that the cemetery at Păuca is contemporary with the final phase of the late Germanic period (Gepids) and with the early Avar period (these are placed between 6$^{th}$ and beginning of 8$^{th}$ century). If we accept that dating the cemetery at Păuca at an upper limit of the interval (7$^{th}$ century) is possible, this could connect it with the events of the period between 567-630, i.e. the establishment and consolidation of the Avar power in the Panonic-Transylvanian area.

The situation could be clarified by continuing the process of dating other samples from the site and also by carrying out dating for other similar cemeteries and comparing these results with dating carried out on samples from contemporary settlements of the Mediaș-type cemetery horizon.

## Conclusions

The study of cremation cemeteries dating back to the 6$^{th}$ and 9$^{th}$ centuries is a necessity from the perspective of analyzing the process of Christianization of the funerary ritual and therefore of clearly establishing the moment of the massive Christianization of the populations of the Central European area. In this context, the cremation cemetery at Păuca-Hungarian Church represents the most recent research of such a cemetery belonging to the so-called *Mediaș group* and the only one that has provided absolute chronological data obtained by dating with $C^{14}$ within this group, thus making it possible to reopen discussions on the chronology and, subsequently, on the ethnic origin of the communities that used the cemeteries.

Based on the 5 samples analyzed, we can say that the cemetery at Păuca - Hungarian Church belonged to a community that most probably used it during the middle part of the 7$^{th}$ century. However, the results may change as other

samples are being analyzed at IFIN-HH and the independent verification of some of them has already been taken into consideration.

**Rezumat**

Cercetările arheologice în situl de la Păuca - Biserica Unguréască au început în 2010, iar între 2010 și 2019 au fost descoperite peste 70 de morminte, unele fiind simple morminte de incinerație cu depunerea de rămășițe în urnă, altele fiind morminte duble (cu două urne) și unul fiind un mormânt dublu mixt (incinerație și înmormântare). Datarea cu $C^{14}$ a celor cinci mostre prelevate din cimitir sugerează că începuturile cimitirului de la Păuca coincid cu perioada târzie germanică (gepizi) și perioada timpurie avară. Admițând că este mai precis să se stabilească o dată mai aproape de limita superioară a intervalului de date furnizat de $C^{14}$ (secolul al VII-lea), cimitirul de la Păuca ar putea fi legat de evenimente istorice au avut loc care între anii 567 și 630, adică stabilirea și consolidarea puterii avarilor în spațiul Panono-Transilvănean. Datarea $C^{14}$ a mormintelor de incinerație de la Păuca (județul Sibiu) redeschide discuția cu privire la necesitatea unui număr mai mare de mostre de date $C^{14}$ din cimitirele de incinerație atribuite așa-numitei grupe Mediaș și în același timp poate reprezenta un punct de cotitură în evaluarea cronologiei perioadei cuprinse între secolele al VI-lea și al VIII-lea d.Hr.

**Cuvinte cheie**: datări $C^{14}$, cimitir de incinerație, grupul Mediaș, perioada migrațiilor, România

**Acknowledgment**

Project partially financed by Lucian Blaga University of Sibiu (Knowledge Transfer Center) & Hasso Plattner Foundation research grants LBUS-HPI-ERG-2023-07

**GÂZA, Oana,** Horia Hulubei National Institute for R&D in Physics and Nuclear Engineering, Măgurele, Ilfov, Romania. E-mail: oana_gaza@yahoo.ro

**ILIE, Maria Valentina,** Horia Hulubei National Institute for R&D in Physics and Nuclear Engineering, Măgurele, Ilfov, Romania. E-mail: maria.ilie@nipne.ro

**MANAILESCU, Cristian,** Horia Hulubei National Institute for R&D in Physics and Nuclear Engineering, Măgurele, Ilfov, Romania. E-mail: cristian.manailescu@tandem.nipne.ro

**SAVA, Tiberiu Bogdan,** Horia Hulubei National Institute for R&D in Physics and Nuclear Engineering, Măgurele, Ilfov, Romania. E-mail: tiberiu.sava@nipne.ro

**SIMION, Corina Anca,** Horia Hulubei National Institute for R&D in Physics and Nuclear Engineering, Măgurele, Ilfov, Romania. E-mail: anke@ifin.nipne.ro

**ȚIPLIC, Ioan Marian,** "Lucian Blaga" University of Sibiu, Centre for Research on Heritage and Socio-Cultural History, Sibiu, Romania. E-mail: ioan-marian.tiplic@ulbsibiu.ro