

RADIOCARBON INVESTIGATION OF TWO OLD ELMS FROM ROMANIA

ADRIAN PATRUT^{a,b *}, ROXANA T. PATRUT^a,
VICTOR BOCOS-BINTINTAN^c, ILEANA-ANDREEA RATIU^{a,b},
LASZLO RAKOSY^d, GEORGE ZDROB^e, EUFROSINA VANCA^f,
KARL F. VON REDEN^g

ABSTRACT. The paper reports the AMS (accelerator mass spectrometry) radiocarbon investigation results of two superlative elms from Romania, the very large field elm of Calafat, with a wood volume of 85 m³, and the wych elm of Sadova. Two wood samples were extracted from each elm and were analysed by AMS radiocarbon. The oldest dated sample from the elm of Calafat had a radiocarbon date of 350 ± 19 BP, which corresponds to a calibrated age of 415 ± 25 years, while the oldest sample from the elm of Sadova had a radiocarbon date of 188 ± 24 BP, corresponding to a calibrated age of 260 ± 25 years. These values indicate high ages for the two elms, namely 430 ± 25 years for the elm of Calafat and 400 ± 25 years for the elm of Sadova.

Keywords: AMS radiocarbon dating, *Ulmus minor*, *Ulmus glabra*, dendrochronology, age determination, Romania.

^a Babeş-Bolyai University, Faculty of Chemistry and Chemical Engineering, 11 Arany Janos, RO-400028, Cluj-Napoca, Romania.

^b Babeş-Bolyai University, Raluca Ripan Institute for Research in Chemistry, 30 Fantanele, RO-400294 Cluj-Napoca, Romania.

^c Babeş-Bolyai University, Faculty of Environmental Science and Engineering, 30 Fantanele, RO-400294 Cluj-Napoca, Romania.

^d Babeş-Bolyai University, Faculty of Biology and Geology, 44 Republicii, RO-400015, Cluj-Napoca, Romania.

^e Campulung Moldovenesc City Hall, 22 Decembrie 1989, RO-72510 Campulung Moldovenesc, Romania

^f Independence High School, 4 Horia, Closca si Crisan, RO-205200 Calafat, Romania

^g NOSAMS Facility, Dept. of Geology & Geophysics, Woods Hole Oceanographic Institution, Woods Hole, MA 02543, U.S.A.

* Corresponding author: apatrut@gmail.com

INTRODUCTION

Elms are deciduous flowering trees, which belong to the genus *Ulmus* L., in the Ulmaceae family. *Ulmus* species are widespread in the temperate regions of the northern hemisphere, i.e., in Northern America, Europe and Asia. In Europe, including Romania, three species are the most common, namely the European white elm (*Ulmus laevis* Pall.), the wych elm (*Ulmus glabra* Huds.) and the field elm (*Ulmus minor* Mill.). Elms grow in broadleaved cool forests, which are found especially near rivers and floodplains [1,2].

The story of elms is strongly marked by two destructive pandemics, determined by the introduction in the 20th century of the highly contagious fungal pathogen *Ophiostoma*. The two pandemics, caused in the 1920s by the micro-fungus *O. ulmi* and in the 1970s by *O. novo-ulmis*, are generally known as the Dutch Elm Disease (DED). The DED, which is one of the deadliest tree diseases, has devastated the elm populations from all over Europe and Northern America. The disease is transmitted by two species of the *Scolytus* elm-bark beetle or throughout the root network, leading to the death of elm trees in 2-3 years [1,2].

In 2005, we started a complex research project focused on elucidating several controversial problems regarding the architecture, growth and age of the African baobab and other baobab species. The research is based on an original method, which is not limited to deceased or fallen trees, but also allows to investigate and date live trees. The method consists of AMS radiocarbon dating of tiny wood samples extracted from different areas of such trees [3-9]. We extended our research by dating trees that belong to other tree species, including specimens from Romania.

Romania hosts several monumental trees, which have large dimensions and/or old ages. Thus, we investigated and dated by AMS radiocarbon some remains of the historic pedunculate oak of Ţebea (deceased in 2005) [10], the large pedunculate oaks of Cajvana, Botoşana and Mercheaşa [11-13], the old black poplar of Mocod (deceased in 2017), the very big grey poplar of Rafaila (deceased in 2015) [14] and the old ash of Aiton [15].

Here we present the investigation and AMS radiocarbon dating results of two old Romanian elms, namely the field elm of Calafat and the wych elm of Sadova.

RESULTS AND DISCUSSION

The field elm of Calafat and its area. The huge historic field elm (*Ulmus minor*) was located on the left shore of the Danube River, at only 5 m from the pier, in the place called Baba Lupa from Calafat, a town in Dolj county, Romania.

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The GPS coordinates are 43°59.971' N, 022°56.232' E and the altitude is 33 m. The mean annual rainfall is 360 mm (Craiova Airport station).

The elm was already a very large tree in the 19th century, during the Independence War (1877–1878). Standing right next to the elm, on May 8, 1877, when a Turkish shell exploded at his feet, the future King Carol I of Romania uttered the memorable words: "This is the music I like!" [16].



Figure 1. General view of the very large field elm of Calafat

In the early 1970s, the elm was investigated and measured by Stoiculescu. The tree had a height of 43 m and the circumference at breast height (cbh; at 1.30 m above mean ground level) was 6.63 m. The trunk was twisted forming clockwise spirals along its entire length. It forked at the height of 4 m into two large branches, with diameters of 1.5 and 1.2 m (**Figure 1**). The canopy, which was asymmetrical, with a lean of over 30° towards the Danube, had a maximum diameter of 28 m and a projected floor area of 616 m². The calculated overall wood volume was 85 m³ (**Figure 2**). The elm grew on alluvial clay-sandy soil, with the groundwater table at a depth of just 2 m [16].

In 2011, the circumference of the big elm was measured again and had a value cbh = 6.70 m.



Figure 2. The photograph shows the twisted trunk of the elm of Calafat

Unfortunately, in February 2015, the historic elm from Baba Lupa was cut down at the order of a local businessman and with the consent of the city's mayor. This irresponsible act on a protected Natural Monument was motivated by the fact that its crown had begun to dry up. The remaining stump, mutilated by the blade of a bulldozer, was completely removed after a few months (**Figure 3**). Ultimately, the elm was used as firewood. Thus ended the dramatic history of one of the largest trees of Romania.



Figure 3. Image of the mutilated stump of the elm of Calafat

The wych elm of Sadova and its area. The multi-centennial wych elm (*Ulmus glabra*) is located in the Sadova village, a suburb of Campulung Moldovenesc city, Suceava county, Romania [17]. It can be found in a private garden, on a slope with south-eastern exposure, at a distance of around 50 m from a stream called Pârâul Morii, very close to its confluence with the Sadova stream. The GPS coordinates are 47°32.619' N, 025°31.573' E and the altitude is 659 m. The mean annual rainfall is 626 mm (Suceava station).

The elm, which has a new canopy with young branches, has a current height $h = 13.8$ m and a circumference $cbh = 6.77$ m (**Figure 4**). Its state is degraded, with the trunk mostly empty inside. The very large hollow extends from the ground up to the maximum height of the trunk, i.e., 5.3 m. The main entrance to the cavity has a height of 1.53 m and a variable width, which does not allow a man to enter inside. The thickness of the dry and partially rotten wood left in the walls of the cavity varies between 0.10 and 0.40 m (**Figure 5**). Only three branches of the original canopy are still standing. They have diameters up to 0.70–0.80 m. The horizontal dimensions of the restored canopy are 18.2 m (WE) x 17.6 m (NS). The current overall wood volume (including the hollow parts) is around 18 m³.



Figure 4. General view of the wych elm of Sadova

Another large hollow elm with a circumference $cbh = 5.03$ can be found at only 24 m toward the north. During the Second World War, in the hollows of the two elms, archival documents of the Câmpulung Moldovenesc Military Circle, a number of 25 weapons, carpets and other valuables were stored. Both elms are protected and have been declared Natural Monuments in 1934.

Wood samples. Two tiny samples, labelled CL-1 and CL-2, were extracted with a sharp instrument from the remaining stump of the elm of Calafat, shortly after it was felled, from an area close to the calculated pith.

One wood sample, labelled SA-1, with the length of 0.15 m was collected with an increment borer from the elm of Sadova, at the height of 1.61 m above ground. Two pieces/segments, each 10^{-3} m long (marked a and b), were extracted from determined positions of the sample SA-1. Another tiny sample, labelled SA-2, was extracted with a sharp instrument from the cavity, at the height of 1.45 m.

AMS results and calibrated ages. Radiocarbon dates of the 5 sample segments are listed in Table 1. The radiocarbon dates are expressed in ^{14}C yr BP (radiocarbon years before present, i.e., before the reference year 1950). Radiocarbon dates and errors were rounded to the nearest year.

Calibrated (cal) ages, expressed in calendar years CE (CE, i.e., common era), are also displayed in Table 1. The 1σ probability distribution (68.3%) was selected to derive calibrated age ranges. For two segments (CL-1, CL-2), the 1σ distribution is consistent with two ranges of calendar years, while for the other two sample segments (SA-1b, SA-2) it corresponds to three and four ranges of calendar years. In all these cases, the confidence interval of one range is considerably greater than that of the other(s); therefore, it was selected as the cal CE range of the segment for the purpose of this discussion.

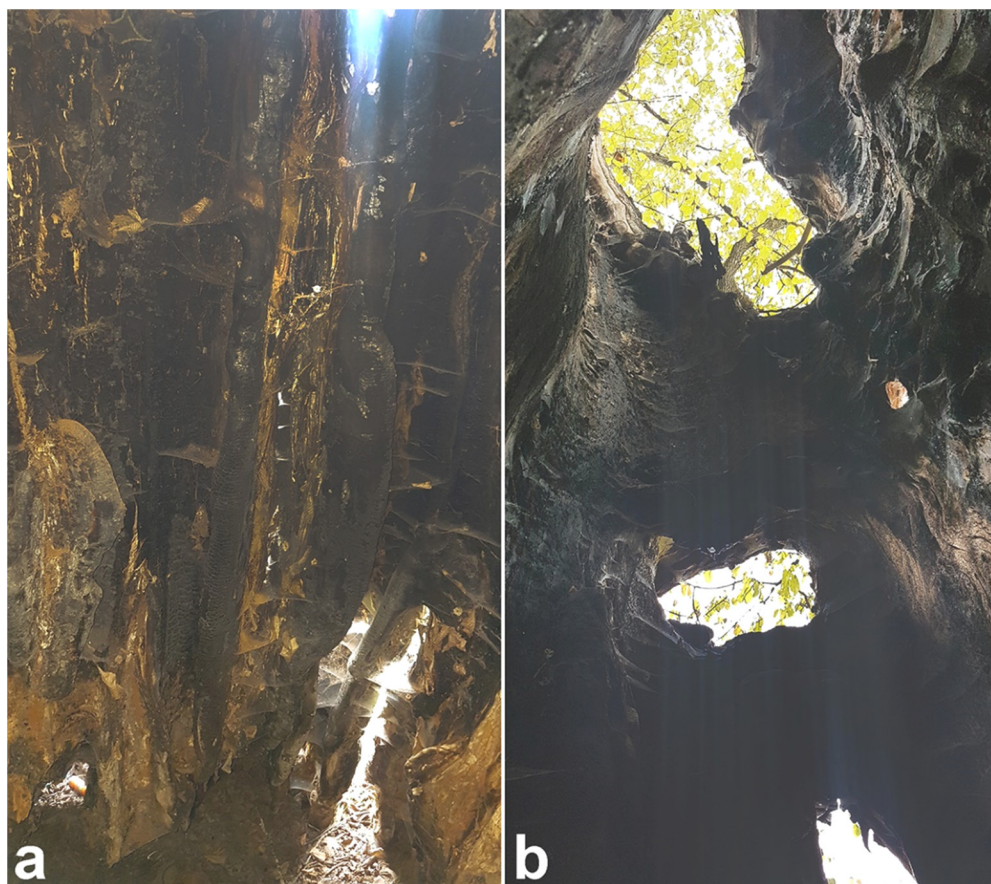


Figure 5a and b. The image shows the lower (a) and upper part (b) of the large inner cavity of the wych elm

Table 1. AMS Radiocarbon dating results and calibrated ages of samples collected from the elm of Calafat (CL) and from the elm of Sadova (SA).

Sample code	Depth ¹ [height ²] (m)	Radiocarbon date [error] (¹⁴ C yr BP)	Cal CE range 1σ [confidence interval]	Assigned year [error] (cal CE)	Sample age [error] (cal CE)
CL-1	1.05 [0.80]	345 [± 20]	1490-1524 [25.7%] 1572-1630 [42.6%]	1601 [± 29]	415 [± 30]
CL-2	1.25 [0.80]	350 [± 19]	1486-1521 [30.0%] 1578-1624 [38.3%]	1601 [± 23]	415 [± 25]
SA-1a	0.05 [1.61]	-	-	> 1950	> Modern
SA-1b	0.12 [1.61]	105 [± 18]	1696-1724 [21.7%] 1812-1838 [19.3%] 1878-1915 [27.2%]	1896 [± 18]	125 [± 18]
SA-2	0.40 [1.45]	188 [± 24]	1664-1682 [14.9%] 1736-1785 [37.9%] 1794-1802 [6.0%] 1936-... [9.5%]	1760 [± 25]	260 [± 25]

¹ Depth in the wood from the sampling point.

² Height above ground level.

For obtaining single calendar age values of sample segments, we derived a mean calendar age of each sample segment, called assigned year, from the selected range (marked in bold). Sample/segment ages represent the difference between the year 2016 CE (for samples CL-1 and CL-2, when the elm of Calafat died) or the current year 2022 CE (for samples SA-1 and SA-2) and the assigned year, with the corresponding error. Sample ages and errors were rounded to the nearest 5 yr. We used this approach for selecting calibrated age ranges and single values for sample ages in our previous articles on AMS radiocarbon dating of large and old angiosperm trees [3-15, 18-21].

Dating results of samples (segments). For the elm of Calafat, the two samples extracted from the mutilated stump, i.e., CL-1 and CL-2, had very close radiocarbon dates of 345 ± 20 BP and 350 ± 19 BP. These values correspond to quasi-identical calibrated ages of 415 ± 30 and 415 ± 25 calendar yr.

For the elm of Sadova, the oldest dated sample SA-2 had a radiocarbon date of 188 ± 24 BP, which corresponds to a calibrated age of 260 ± 25 calendar yr. The deepest end of sample SA-1, namely SA-1b, had a radiocarbon date of 105 ± 18 BP, corresponding to a calibrated age of 125 ± 18 calendar yr. The negative radiocarbon date and the age of segment SA-1a shows that the elm of Sadova grew the last 0.05 m in radius in less than 72 years.

Age of the field elm of Calafat. The two samples CL-1 and CL-2, which have practically identical ages, namely 415 years (in 2016), were collected from an area which includes the calculated pith of the stump, at a distance of 0.20 m from each other. These results suggest that the true pith was positioned between the two sampling points. All these data indicate an age of 430 ± 25 years for the elm of Calafat in 2016, when it was cut down. It should be noted the excellent state of vegetation of the field elm of Calafat, whose stump did not have hollow parts. Typically, very large and old elms have their trunk mostly hollow, with little wood left in the cavities. It is worthful to mention that for almost 40 years, between the measurements of Stoiculescu and our measurements, the elm of Calafat increased in circumference by only 0.07 m, i.e., from 6.63 to 6.70 m. This value indicates a very old age.

Age of the wych elm of Sadova. The oldest sample SA-2 was extracted from the large inner cavity, at a depth in the wood of 0.40 m from the bark and at a height of 1.45 m above ground. At this height, the diameter of the tree is 2.10 m, which corresponds to a radius of 1.05 m. Taking into account that young elms grow fast, while old elms grow very slowly, we estimate that the age of sample SA-2, namely 260 years, represents around 65% of the true age of the tree. Therefore, we consider that the wych elm of Sadova is 400 ± 25 years old.

CONCLUSIONS

Our research discloses the AMS radiocarbon dating results of the giant field elm of Calafat, with a wood volume of 85 m^3 , and of the wych elm of Sadova. Two samples were extracted from each elm. The radiocarbon date of the oldest sample collected from the elm of Calafat was 350 ± 19 BP, which corresponds to a calibrated age of 415 ± 25 calendar years. The oldest sample from the elm of Sadova had a radiocarbon date of 188 ± 24 BP, corresponding to a calibrated age of 260 ± 25 calendar years. These results, combined with the original positions of the dated samples in the trees, indicate an age of 430 ± 25 years for the elm of Calafat and 400 ± 25 years for the elm of Sadova.

EXPERIMENTAL SECTION

Sample collection. The sample SA-1 was collected with a Hagl6f CH 800 increment borer (0.80 m long, 0.0108 m inner diameter). A number of two tiny pieces/segments were extracted from predetermined positions along

the sample. The other three small samples, i.e., CL-1, CL-2 and SA-2, were extracted from predetermined positions with a sharp instrument. The sample/segments were processed and investigated by AMS radiocarbon dating.

Sample preparation. The α -cellulose pretreatment method was used for removing soluble and mobile organic components [22]. The resulting samples were combusted to CO₂, which was next reduced to graphite on iron catalyst [23,24]. The resulting graphite samples were analysed by AMS.

AMS measurements. AMS radiocarbon measurements were performed at the NOSAMS Facility of the Woods Hole Oceanographic Institution (Woods Hole, MA, U.S.A.) by using the Pelletron® Tandem 500 kV AMS system [25]. The obtained fraction modern values, corrected for isotope fractionation with the normalized $\delta^{13}\text{C}$ value of -25 ‰ , were ultimately converted to a radiocarbon date.

Calibration. Radiocarbon dates were calibrated and converted into calendar ages with the OxCal v4.4 for Windows [26], by using the IntCal20 atmospheric data set [27].

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