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AFRICAN BAOBABS WITH DOUBLE CLOSED RING-SHAPED STRUCTURES AND TWO SEPARATE FALSE CAVITIES: RADIOCARBON INVESTIGATION OF THE BAOBAB OF GOLCONDA FORT

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ABSTRACT. The article discloses the results of radiocarbon investigation of the baobab of Golconda Fort, Hyderābād, India, which is the largest African baobab outside Africa. Two wood samples were collected from the large inner cavity; of these we extracted several segments for AMS (accelerator mass spectrometry) radiocarbon dating. The oldest sample segment had a radiocarbon date of 342 ± 22 BP, which corresponds to a calibrated age of 430 ± 20 yr. We estimate that the oldest part of the baobab has an age of 475 ± 50 yr. The investigation of the baobab of Golconda Fort revealed that it consists of 6 + 2 fused stems. Six stems build two rings that close two distinct false cavities, while two additional stems are located outside the rings. We called this new type of architecture double closed ring-shaped structure with two separate false cavities.

Keywords: *AMS radiocarbon dating, Adansonia digitata, tropical trees, age determination, inner cavity, multiple stems.*

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INTRODUCTION

The African baobab (*Adansonia digitata* L.), which is the largest and best-known of the nine *Adansonia* species, has a natural distribution in continental Africa between the latitudes 16º N and 26º S. It also found outside Africa, in different areas throughout the tropics, where it was introduced [1-3]. Recent genetic research suggests multiple introduction from different regions of Africa in the Indian subcontinent, possibly extending back to prehistoric times [4].

In 2005, we started a long-term research aimed to clarify several controversial aspects of the architecture, growth and age of the African baobab. Our methodology consists of AMS (accelerator mass spectrometry) radiocarbon dating of small wood samples collected from inner cavities, but also from deep incisions in the stems, fractured stems and from the exterior of large baobabs [5-8]. According to dating results, all large baobabs are multi-stemmed. Radiocarbon investigation of big and old baobabs has demonstrated that their architectures may be very complex. We discovered the open and closed ring-shaped structures, which are the most important architectures that enable African baobabs to reach old ages and large sizes [9,10]. We identified the false cavities, which are large natural empty spaces between fused stems disposed in a closed ring-shaped structure. In a previous work, we described a new version of the closed ring-shaped structure, i.e., baobabs with two closed rings and two interconnected false cavities [11].

Here we describe another kind of closed ring-shaped structure, namely baobabs with two closed rings and two separate false cavities. As a model tree relevant to this type we selected the baobab of Golconda Fort, Hyderābād, India.

RESULTS AND DISCUSSION

The baobab of Golconda Fort and its area. This large baobab is located within the *Naya Qila* (in Hindi, i.e., "New Fort"), an extended area of the medieval Mogul Empire Golconda Fort, a famous citadel and fort, which is considered to be an archaeological treasure of the world. The *Golconda (Golkonda) Fort* (from *Golla Konda* in Telugu, i.e., "Shepherd's Hill") can be found in the metropolitan area of Hyderābād (Greater Hyderābād), the capital of the state Andhra Pradesh, India. The GPS coordinates of the baobab are 17º23.575' N, 078º24.657' E and the altitude is 518 m. Mean annual rainfall in the area is 812 mm.

The historic baobab of Golconda Fort, also called *Hatiyan ka Jhad* (in Hindi, i.e., "Elephant size tree"), has a maximum height of 19.2 m, the circumference at breast height (cbh; at 1.30 m above ground level) is 25.48 m and the overall wood volume (including the false cavitlies) is around 230 m^3 (**Figures 1 and 2**). By these dimensions, the baobab of Golconda Fort is by far the biggest baobab outside Africa.

Figure 1. General view of the baobab of Golconda during the dry season.

The impressive trunk consists of 6 + 2 fused stems. Six stems build the two rings that close two separate false cavities covered by bark. Two additional stems, called the elephant ears, are outside the rings. The largest cavity is accessible via a high somewhat trapezoidal opening, which is positioned at a height of 4.10 m above ground and has diagonals of 0.90 – 1.10 m. This high opening is the upper part of an inclined tube with stairs, which descends into a small antechamber that leads via a door into the cavity. The large false cavity has a quasi-ellipsoidal base, with four axes of 2.66 x 2.93 x 3.45 x 3.48 m, a height of 4.28 m and a volume of around 20 m^3 **(Figure 3).** The small cavity also has a high opening in the ceiling, at the height of 4.50 m. Because its diametre is only 0.40 m, the access in the second cavity is not possible. This small cavity has a basal diametre of around 1.2 m and an appendix-like extension of 4 x 2 m. The canopy has two distinct units, which correspond to the two rings; its horizontal dimensions are 31.2 x 26.2 m.

Figure 2. The baobab of Golconda with the canopy full of leaves.

Wood samples. Two wood samples (labelled 1 and 2) were collected from the eastern and western walls of the large false cavity, at convenient heights of 1.43 and 1.35 m. The sample lengths were 0.55 and 0.52 m. A number of five small pieces/segments, each of the length of 0.001 m (marked as a, b, c), were extracted from determined positions of the two samples. We also extracted a very short sample from the outer part of the stem with the high opening toward the large cavity (labelled 11), which consisted mainly of the outermost rings. The sampling height was 1.40 m.

Figure 3. View from top to bottom of the largest false cavity of the baobab of Golconda, which is defined by 4 stems. One can remark the typical rounded ceiling. Humans had used it for decades as a shelter.

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

Table 1. AMS Radiocarbon dating results and calibrated calendar ages of samples/segments collected from the baobab of Golconda.

Sample (Segment)	Depth[1] [height[2]] (10^{-2} m)	Radiocarbon date [error] (^{14}C yr BP)	Cal AD range 1-σ [confidence interval]	Sample age [error] (cal yr)
1a	0.5 [143]	–	–	>Modern
1b	30 [143]	240 [± 24]	**1646-1665 [50.8%]** 1785-1794 [17.4%]	360 [± 30]
1c	55 [143]	342 [± 22]	1490-1524 [23.5%] **1558-1602 [30.3%]** 1601-1631 [14.4%]	435 [± 20]
2a	0.5 [135]	–	–	>Modern
2b	52 + x [135]	338 [± 22]	1494-1524 [21.7%] **1558-1602 [33.9%]** 1615-1631 [12.6%]	435 [± 20]
11a	0.5 [140]	–	–	>Modern

[1] Depth in the wood from the sampling point.
[2] Height above ground level.

Calibrated (cal) ages, expressed in calendar years, are also presented in Table 1. The 1-σ probability distribution was selected to derive calibrated age ranges. For two sample segments, the 1-σ distribution is consistent with three ranges of calendar years, while for one segment it corresponds to two ranges of calendar years. For these segments, the confidence interval of one range is considerably greater than that of the other(s); therefore, it was selected as the cal AD range of the segment for the purpose of this discussion. For obtaining single calendar age values of sample segments, we derived a mean calendar age of each segment from the selected range (marked in bold). Calendar ages of segments represent the difference between AD 2016 and the mean value of the selected range, with the corresponding error. Calendar ages and errors were rounded to the nearest 5 yr. For three segments, ages fall after AD 1950 (0 BP), namely the ^{14}C activity, expressed by the ratio $^{14}C/^{12}C$, is greater than the standard activity in the reference year 1950. Such values correspond to negative radiocarbon dates and are termed greater than Modern (>Modern). In these cases, the dated wood is young, being formed after AD 1950.

Dating results of samples (segments). We extracted and dated three segments from sample 1, which was continuous/unbroken. The deepest and oldest segment 1c, which was also the sample end, originates from a distance of 0.55 m from the sampling point. Its radiocarbon date of 342 ± 22 BP corresponds to a calibrated age of 435 ± 20 calendar yr. The segment 1b, originating from a distance of 0.25 m into the wood, had a radiocarbon date of 240 ± 24 BP and a calibrated age of 435 ± 20 yr. Two segments were extracted and dated from sample 2, which was 0.52 m long; given that sample 2 was broken, it consisted of three parts. The sample end 2b, corresponding to a distance of (0.52 + x) m into the wood (where x = length of the two missing parts from sample 2), had a radiocarbon date almost identical with that of segment 1c, i.e., 338 ± 22 BP, and a calibrated age of 435 ± 20 yr. The ages of three segments, which consist of the innermost rings (for 1a and 2a) and outermost rings (for 11), fall after AD 1950. These values demonstrate that the corresponding stems continued growing toward the interior and exterior at least for a time period after 1950.

Architecture of the baobab of Golconda Fort. The large trunk has a kind of irregular platform at the height of 4.0 – 4.5 m, where the openings toward the two cavities are located and from where the tree can be inspected. From this platform we counted the stems, which still show some obvious fusion lines. We found that there are six stems which build the two rings, while two other younger stems are outside the rings. The two separate false cavities are both covered by bark. The first false cavity is defined by four stems and the second cavity by three stems, while one stem is shared by both cavities. For the two samples collected from the largest cavity, the age values of segments increase with the depth into the wood; this anomaly is characteristic only to false cavities [10-16]. We called this new type of baobab architecture double closed ring-shaped structure with two separate false cavities.

Age of the baobab of Golconda Fort. For baobabs with closed rings, the age sequence of samples collected from false cavities shows a continuous increase from the cavity walls up to a certain distance into the wood, which corresponds to a point/area of maximum age [10,11]. It is obvious that the age of the oldest part of the baobab must be greater than the age of the oldest dated sample(s), i.e., 435 ± 20 yr. The lengths of the two samples collected from the largest false cavity, namely 0.55 and 0.52 m, were considerably shorter than the increment borer (0.80 m), revealing that both samples end in hollow parts. The width of the cavity walls is between 1.40-1.60 m for the western wall (sample 1) and is unknown for the eastern wall (sample 2). These data suggest that the end of sample 1 is relatively close to the point of maximum age. Therefore, we believe that in this point, which is hollow, the age would be of around 450 – 500 yr. By also considering the errors, we estimate that the age of the western stem of the largest cavity, which could be one of the oldest, is 475 ± 50 yr. According to the shape and dimensions of stems and cavities, we also estimate that the six stems which build the two rings have close ages, probably between 400 – 500 yr. On the other hand, the two stems outside the rings, the so-called elephant ears, must be younger. The ages of samples 1b and 1c, namely 435 and 360 yr, demonstrate that the western stem of the large cavity grew very fast when it was young, i.e., by 0.25 m toward the cavity in 75 yr, after which it grew by only 0.30 m over the next 360 yr.

CONCLUSIONS

The research reports the AMS radiocarbon investigation of the largest African baobab outside Africa, i.e., the baobab of Golconda Fort, Hyderābād, India. Two wood samples were collected from the walls of the largest inner cavity. The age values of segments extracted from these samples increase with the distance into the wood, showing an anomaly which is specific to false cavities. The oldest segment had a radiocarbon date of 342 ± 22 BP and a calibrated age of 430 ± 20 yr. We estimate that the big baobab has an age of 475 ± 50 yr and was planted outside the old Golconda Fort around AD 1540. Naya Quila was built more than a century later, in 1656. Our investigation has identified a new type of the closed ring-shaped structure, which was called double closed ring-shaped structure with two separate false cavities. The baobab of Golconda Fort consists of eight stems. Six stems build the two rings with two false cavities inside.

EXPERIMENTAL SECTION

Sample collection. Sample preparation. AMS measurements. See our first article in this issue [17].

Calibration. Radiocarbon dates were converted into calendar ages with OxCal v4.2 for Windows [18], using the IntCal13 atmospheric set [19].

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