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RADIOCARBON DATING OF A SERIES OF THE HEADS OF EGYPTIAN MUMMIES FROM THE MUSÉE DES CONFLUENCES, LYON (FRANCE)

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ABSTRACT. As part of a multidisciplinary project concerning the practices of mummification in ancient Egypt, we studied a series of 33 human remains, collected during the late 19th century. These heads of human mummies belong to the Osteology collection from the Musée des Confluences of Lyon. One of the important issues of this research project was to establish a chronology of the mummification processes. However, the lack of archaeological data and excavation reports does not allow the dating of the specimens. Thus, during this project, these heads have been radiocarbon dated in order to place the individuals in a reliable chronological and cultural framework. As a result, 20 samples of hair and 13 samples of linen textiles of the wrappings have been taken. The results raised a lot of uncertainties about the chronology of these mummies and the need to validate or correct the original date attributions were given by the discoverers. As an example, among the 13 mummies thought to be dated between the 11th and 20th Dynasties, none appears from this period. In the same way, six mummies were originally dated from the Ptolemaic period. However, only one belongs to this period, four are Roman, and the last one is from the New Kingdom.

KEYWORDS: AMS dating, mummies, Egypt, Confluences Museum.

INTRODUCTION

The collection of Osteology of the Musée des Confluences consists of 250 heads and skulls of Egyptian mummies. These human remains were collected during the late 19th and early 20th century in Upper Egypt by Charles-Louis Lortet (1836–1909) and by the anthropologist Ernest Chantre (1843–1924). Ch-L Lortet was the first dean of the Faculty of Medicine of Lyon and then director of the Natural History Museum of Lyon. Only the heads of the mummies were brought to France to enrich the anthropological collections of the museum (Chantre 1904). Therefore, much of the information related to the mummification of the bodies, their burial sites, and their possible identities has been lost forever. The origin and the dating of these mummies were given by their discoverers without reference to any excavation or a particular tomb.

Some of these heads have been subjected to several scientific studies like radiology, paleopathology, anthropology, etc. (Herzberg and Perrot 1983; Perraud 2012, 2013). More recently, an isotopic study was performed on a few of them in order to track the diet of ancient Egyptians (Touzeau et al. 2014) and to evaluate the increasing aridity in the Nile Valley in ancient Egypt (Touzeau et al. 2013).

The present research is part of a multidisciplinary project about the practices of mummification in ancient Egypt. The aim is to determine the evolution of mummification through the study of museum mummies. Furthermore, the geographical origins are unknown for most of them. One of the important aims of this project was to establish the chronology of the mummification process of the heads, including the brain extraction, the filling of the skull with balm, the use of linen textile for the wrappings, and the packing of the eye cavities and the nostrils with pads. However, the lack of archaeological data or excavation reports makes dating the specimens

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impossible, and we cannot provide objective conclusions concerning the chronology of mummification protocols.

The only data available were those attributed by the discoverers without any written proof: the heads were "dated" between the 11th Dynasty and the Ptolemaic period. Thus, they defined four periods within ancient Egyptian chronology (Hornung et al. 2006):

- a first phase extended from the 11th until the 20th Dynasty (~2025–1077 BC), forming a large range between the Middle Kingdom and the New Kingdom;
- a second phase corresponding to the 18th Dynasty (~1540–1292 BC) of the New Kingdom;
- a third one to the 26th Dynasty (~664–525 BC) of the Late Period;
- and the last is the Ptolemaic period (~332–30 BC).

The series of heads have been ^{14}C dated in order to put individuals in a reliable chronological and cultural framework. If possible, hair samples were taken, a powerful biological indicator, which can provide useful information about the lifestyle of the individual. We have applied a preparation protocol for hair, based on the selective extraction of keratin from cortex (Richardin et al. 2011). This method has been used successfully on a large number of mummies from museum collections (Richardin et al. 2013; Diaz et al. 2015).

EXPERIMENTAL

Sampling

The studied mummy heads are in a variable state of conservation (Figure 1). Some heads have not been unwrapped and are completely covered with linen textile (Figure 1a). Others have conserved all their biological tissues and also their hair (Figure 1b,c), while some have been damaged by keratinophage insects and are in a poor state of conservation (Figure 1d). Finally, skin, teeth, and also some hair were removed from heads (Figure 1e, f) where only a few organic tissues or linen textiles remain.

For this reason, hair samples were collected and sometimes when hair was not accessible (totally wrapped mummies), linen textile samples were taken. In total, 20 samples of hair and 13 samples of linen textiles were taken for ^{14}C dating.

Sample Preparation

The main difficulty for ^{14}C dating of samples taken from Egyptian mummies is, of course, the contamination during the mummification process (due to the use of mineral salts, balms, resins, oils, etc.). Moreover, the fluids produced by the decomposition of the body complicate the dating. Therefore, the extraction of these exogenous organic compounds must be properly controlled to avoid perturbations during the ^{14}C dating of samples (Quiles et al. 2014).

The efficiency of protocols used for the extraction of amorphous organic compounds from archaeological artifacts is well established. These methods, based on solvent extractions, were set up in 1959 (Bligh and Dyer 1959) and slightly modified to be applied for chromatographic analyses in archaeology (Regert 2011; Garnier 2014). In a recent paper (Richardin and Coudert 2016), we have taken several samples from an Egyptian mummy and its associated burial material. Extraction with solvents, if the latter are correctly eliminated with pure water, does not affect the results of ^{14}C dating, as it has been shown on keratin extracted from hair, linen textiles, and vegetal samples (leaves). Indeed, all the ^{14}C dates obtained are similar. All samples

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Figure 1 Photographs of six heads of mummies of the Confluences Museum, showing the diversity of mummification techniques and states of conservation: (a) Inv 30000141_B38; (b) Inv 30000121; (c) Inv 30000113_B10; (d) Inv 30000106_B8; (e) Inv 3000102_B3; and (f) Inv 30000151_B48.

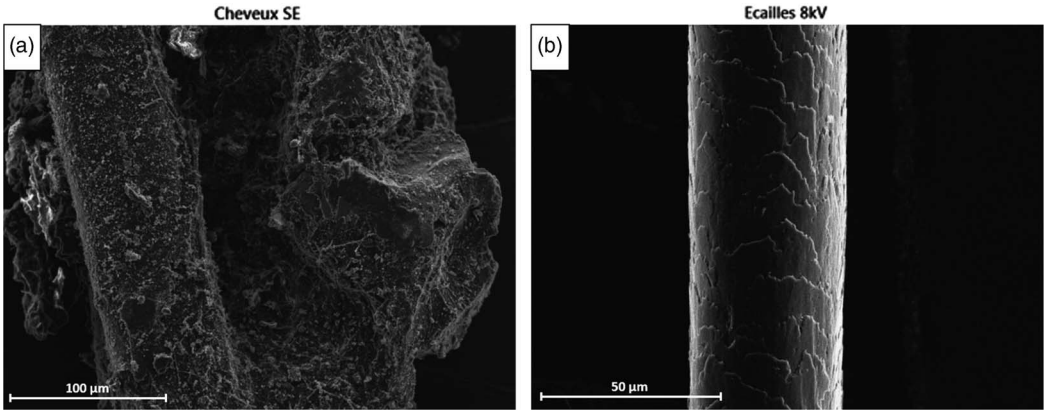

Figure 2 SEM-SE image of hair taken on the mummy head (Inv. 30000111) before (a) and after (b) the cleaning procedure.

were thus subjected to the same protocol (Richardin and Gandolfo 2013a, 2013b): a successive washing with ultrapure water (Direct-Q system from Millipore), then a mixture of methanol/dichloromethane (v/v 1/1) (for analysis, VWR International), and finally with acetone (AnalaR Normapur, VWR International) in an ultrasonic bath for 10 min. After the last treatment, samples were thoroughly rinsed three times with ultrapure water. This protocol was applied with success on very impregnated hair. Scanning electron microscope (SEM) images (recorded on a Phillips XP CL 30 series) on a hair sample (Figure 2) show the efficiency of the cleaning procedure.

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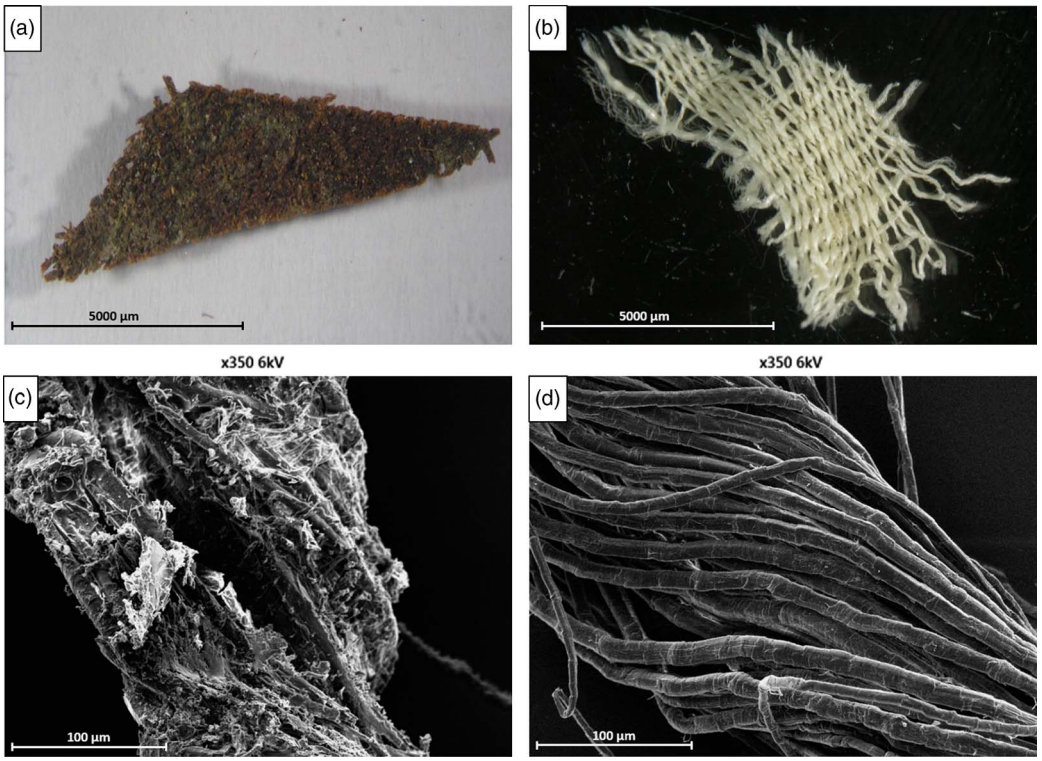

Figure 3 Photographs of a textile sample (taken on head Inv. 30000103) before (a) and after pretreatments (b). SEM-SE image of a few fibers before (c) and after (d) the cleaning procedure.

Keratin from hair samples was extracted (Richardin et al. 2011) according to a routine procedure we use in the laboratory and applied to various samples (Richardin et al. 2013; Díaz-Zorita Bonilla et al. 2016). Linen textiles were subjected to an acid-alkali-acid treatment followed by an oxidative bleaching with $NaClO_2$. Figure 3 shows the binocular photographs and the SEM images of an impregnated linen textile sample before and after these pretreatments, showing their efficiency.

Some 2–2.5 mg of the dried samples were combusted for 5 hr at 850°C under vacuum in a quartz tube with CuO and a piece of silver wire. The CO_2 was collected in a sealed tube. Graphitization of the CO_2 gas was performed at the LMC14 laboratory of Saclay (France) with a routine protocol (Moreau et al. 2013).

Radiocarbon Measurements and Calibration

All measurements were performed with the Artemis AMS facility at Saclay (France) (Moreau et al. 2013). Calendar ages are determined using the OxCal v 4.2 procedure (Bronk Ramsey 2009) and the most recent calibration curve data for the Northern Hemisphere, IntCal13 (Reimer et al. 2013).

RESULTS

All the ^{14}C ages and calibrated dates of hair and linen textile samples are given in Table 1. Among all the studied human remains, only one sample seems to stand out. Indeed, the date

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Table 1 ^{14}C age and calibrated age of all samples.

Supposed date	Inventory nr	Type of sample	^{14}C age (yr BP)	Calibrated age (2σ)	Attributed period
11th to 20th Dynasty (Middle Kingdom to New Kingdom)	30000108	Textile	2280 ± 30	403 cal BC (60.1%) 352 cal BC 296 cal BC (33.5%) 228 cal BC 221 cal BC (1.8%) 211 cal BC	End of the Late Period–Beginning of the Ptolemaic period
	30000109	Hair	1718 ± 22	252 cal AD (95.4%) 389 cal AD	Roman period
	30000112	Hair	1810 ± 22	130 cal AD (92.7%) 254 cal AD 302 cal AD (2.7%) 315 cal AD	Roman period
	30000113	Hair	1845 ± 35	78 cal AD (95.4%) 244 cal AD	Roman period
	30000115	Hair	2040 ± 30	162 cal BC (6.9%) 131 cal BC 118 cal BC (88.1%) 26 cal AD 44 cal AD (0.4%) 46 cal AD	End of Ptolemaic period–Beginning of the Roman period
	30000116	Textile	1890 ± 30	56 cal AD (95.4%) 217 cal AD	Roman period
	30000117	Hair	1820 ± 30	90 cal AD (1.0%) 100 cal AD 124 cal AD (90.7%) 257 cal AD 296 cal AD (3.7%) 320 cal AD	Roman period
	30000128	Textile	2515 ± 30	792 cal BC (26.6%) 727 cal BC 719 cal BC (1.8%) 704 cal BC 695 cal BC (66.9%) 541 cal BC	End of the Third Intermediate period–Middle of the Late Period
	30000129	Hair	2130 ± 30	350 cal BC (10.5%) 308 cal BC 210 cal BC (84.9%) 52 cal BC	Ptolemaic Period
	30000132	Textile	2495 ± 30	783 cal BC (95.4%) 517 cal BC	End of the Third Intermediate period–Middle of the Late Period
	30000136	Hair	2085 ± 30	192 cal BC (95.4%) 40 cal BC	Ptolemaic period
	30000141	Textile	2480 ± 30	754 cal BC (26.7%) 680 cal BC 670 cal BC (15.5%) 608 cal BC 595 cal BC (53.2%) 411 cal BC	End of the Third Intermediate period–Middle of the Late Period
	30000145	Textile	2335 ± 30	792 cal BC (26.6%) 727 cal BC 719 cal BC (1.8%) 704 cal BC 695 cal BC (66.9%) 541 cal BC	Late Period

Table 1 (*Continued*)

Supposed date	Inventory nr	Type of sample	^{14}C age (yr BP)	Calibrated age (2σ)	Attributed period
18th Dynasty (New Kingdom)	30000110	Hair	1750 ± 22	234 cal AD (94.2%) 349 cal AD 370 cal AD (1.2%) 377 cal AD	Roman period
	30000111	Hair	2003 ± 22	46 cal BC (95.4%) 54 cal AD	Roman period
	30000121	Hair	2390 ± 30	728 cal BC (1.9%) 715 cal BC 708 cal BC (2.3%) 694 cal BC 542 cal BC (91.3%) 396 cal BC	Late Period
	30000144	Hair	2025 ± 30	151 cal BC (0.9%) 143 cal BC 112 cal BC (94.5%) 55 cal AD	End of Ptolemaic period–Beginning of the Roman period
26th Dynasty (Late Period)	30000102	Hair	1719 ± 25	251 cal AD (95.4%) 390 cal AD	Roman period
	30000103	Textile	2163 ± 22	356 cal BC (46.7%) 284 cal BC 256 cal BC (0.5%) 250 cal BC 235 cal BC (46.0%) 156 cal BC 134 cal BC (2.1%) 116 cal BC	Ptolemaic period
	30000105	Textile	2450 ± 30	754 cal BC (26.7%) 680 cal BC 670 cal BC (15.5%) 608 cal BC 595 cal BC (53.2%) 411 cal BC	End of the Third Intermediate period–Middle of the Late Period
	30000106	Hair	1910 ± 50	20 cal BC (1.1%) 11 cal BC 2 cal BC (94.3%) 232 cal AD	Roman period
	30000125	Textile	2195 ± 30	363 cal BC (95.4%) 183 cal BC	Ptolemaic period
Ptolemaic period	30000114	Hair	2030 ± 30	156 cal BC (2.7%) 137 cal BC 114 cal BC (92.7%) 52 cal AD	End of Ptolemaic period–Beginning of the Roman period
	30000119	Hair	1950 ± 30	21 cal BC (2.6%) 10 cal BC 2 cal BC (92.8%) 125 cal AD	Roman period
	30000122	Textile	3120 ± 35	1492 cal BC (1.6%) 1482 cal BC 1454 cal BC (93.8%) 1285 cal BC	New Kingdom
	30000138	Hair	2195 ± 30	363 cal BC (95.4%) 183 cal BC	Ptolemaic period
	30000139	Hair	2010 ± 30	92 cal BC (4.2%) 68 cal BC 61 cal BC (91.2%) 65 cal AD	End of Ptolemaic period–Beginning of the Roman period

	30000140	Textile	1915 ± 30	16 cal AD (93.3%) 140 cal AD 155 cal AD (1.0%) 168 cal AD 195 cal AD (1.1%) 208 cal AD	Roman period
Unknown	30000104	Textile	2270 ± 30	400 cal BC (49.3%) 350 cal BC 304 cal BC (46.1%) 210 cal BC	End of the Late Period–Beginning of the Ptolemaic period
	30000133	Textile	2245 ± 30	392 cal BC (27.9%) 346 cal BC 321 cal BC (67.5%) 206 cal BC	End of the Late Period–Beginning of the Ptolemaic period
	30000127	Hair	2170 ± 30	360 cal BC (92.9%) 156 cal BC 134 cal BC (2.5%) 116 cal BC	Ptolemaic period
	30000126	Hair	2010 ± 30	92 cal BC (4.2%) 68 cal BC 61 cal BC (91.2%) 65 cal AD	End of Ptolemaic period–Beginning of the Roman period
	30000151	Hair	1985 ± 30	46 cal BC (95.4%) 74 cal AD	Roman period

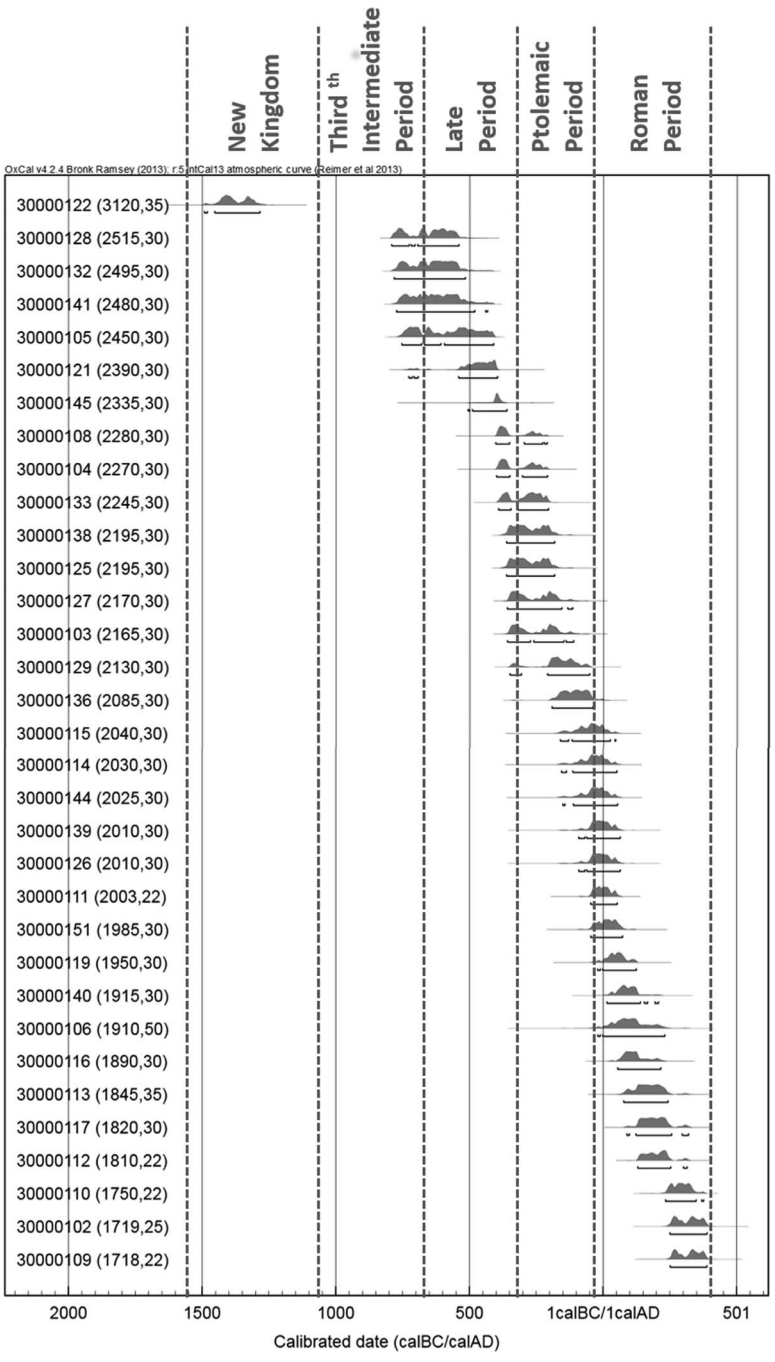

Figure 4 Calibrated dated obtained for the mummies, according the Pharaonic Dynasties in Egypt

obtained for this linen textile sample taken on the mummy head Inv. 30000122 is 3120 ± 35 yr BP (1492–1285 cal BC, 95.4%). It thus seems that the mummy is from the New Kingdom in ancient Egyptian history, a period between 1550 and 1070 BC, which corresponds to the 18th until the

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20th Dynasty. The brain has been removed from the skull, and a little quantity of balm (a mixture of colophony and beeswax) has been poured into the cranium, which is filled with a linen textile. These mummification practices are more ancient than those used during the Ptolemaic period (Dunand and Lichtenberg 2001), the period attributed to the mummy by the archaeologists.

Therefore, except for this last sample, the range of dates obtained for all the mummies is between 2515 ± 30 yr BP (for mummy Inv. 30000128) and 1718 ± 22 yr BP (for mummy Inv. 30000109), a range spanning close to a millennium (Figure 4). These data correspond to a period from the Third Intermediate period (~1077–655 BC) until the Roman period (~30 BC until AD 395). We quickly concluded that the dates assigned to the majority of the mummies were wrong.

The first series of 13 mummies were supposed to be dated between the 11th and 20th Dynasty (~1980–1077 BC, so from Middle Kingdom until New Kingdom). However, none appears from this period. Three of them (Inv. 30000128, 30000132, and 30000141) are from the end of the Third Intermediate period to the middle of the Late Period (~664–332 BC). Two mummies (Inv. 30000145 and Inv. 30000108) belong to the Late Period, and three of them (Inv. 30000129, 30000136, and 30000115) to the Ptolemaic period, whereas the five others date from the Roman period (Inv. 30000116, 30000113, 30000117, 30000112, and 30000109).

A group of four mummies supposed to date from the 18th Dynasty are indeed more recent: Inv. 30000121 (728–396 cal BC) is dated from the Late Period, Inv. 30000144 (112–55 cal BC) from the end of the Ptolemaic period to the beginning of the Roman period, and the last two mummies (Inv. 30000111, 30000110) are Roman.

All four mummies originally supposed to date from the 26th Dynasty are more recent: Inv. 30000105 (2450 ± 30 BP, 754–411 cal BC) is dated from the end of the Third Intermediate period to the middle of the Late Period, Inv. 30000125 (2195 ± 30 BP, 363–183 cal BC) from the Ptolemaic period, and Inv. 30000106 and 30000102 are Roman (1910 ± 30 BP, 20 cal BC–cal AD 232 and 1719 ± 30 BP, cal AD 251–390, respectively).

Among the six mummies originally dated from the Ptolemaic period, only one (Inv. 30000138) belongs to this period. Four others are Roman (Inv. 30000114, 30000144, 30000119, and 30000140), but the other one (Inv. 30000122), cited above, is the oldest of the series studied, belonging to the New Kingdom. However, Inv. 30000104 and 30000133, which are from the end of the Late Period to the beginning of the Ptolemaic period, the last three undated mummies are all from the Ptolemaic period or the Roman period (Inv. 30000127, 30000126, and 30000151).

The late Roman period was not considered by the discoverers, even though mummies from this historic period are the most frequently excavated. Indeed, in this period, mummification was practiced in all the social classes, and burials were less rich. Thus, grave robbers were less interested in them. It is also possible that these mummies were deposited in ancient tombs, which were thus reoccupied, giving incorrect information about their age.

CONCLUSION

This work is the first large ^{14}C dating project on the heads of mummies from the Confluences Museum. Except for one mummy from the New Kingdom (~1540–1077 BC), the range of dates obtained is between approximately 800 BC and AD 400, a range of close to a millennium. These data correspond to a time from the end of the Third Intermediate period (~1069–655 BC) until the Roman period (~AD 30–395). Hence, the majority of the mummies are from more recent times.

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The results allowed us to make conclusions about the chronology of this series and, in particular, revealed a lot of errors in attribution. Overall, we have shown that the attributed dates have often overestimated the age of the mummies. Indeed, for example, among the 13 mummies supposed to be dated between the 11th and the 20th dynasty, none corresponds to this period. The four mummies, dated as from the 26th Dynasty, also called the Saite period, are also more recent, i.e. from the end of the Third Intermediate period until the Ptolemaic period. The discoverers were probably motivated by an anthropological interest since they only took the mummies' heads without studying the archaeological context and the funerary practices of ancient Egypt. They did not make excavation reports and consequently a large quantity of information about the deceased was lost.

At the end of this study, the dates of a series of mummies, previously undated, were correctly attributed. They are almost all from recent periods (Ptolemaic and Roman). For this reason, this project will be continued with the ^{14}C dating of other mummies, in order to obtain data on earlier periods, which could reveal other funerary practices.

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