Charlie 'unwrapped': a scientific investigation of a mummified votive offering in the Australian Institute of Archaeology collection

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Abstract: The research undertaken on the mummified animal (IA1.2402) to establish its authenticity, identity, age and provenance is described. A combination of established and novel non-destructive imaging techniques, including X-ray computed tomography (CT) and neutron computed tomography (NCT) made possible a detailed study of the mummy's content, which was found to be a partial skeleton of a juvenile cat. Use of both techniques allowed for dual contrast and complementary study of bones, soft tissue, and textile components. NCT provided valuable insights into wrapping techniques used in the mummification process. Acquisition of radiocarbon dates provided quantitative results to compare with morphological observations and conclusions based on partiality of the contents. All techniques were employed to better define and profile the specimen within its historical, social and religious contexts, while causing as little physical disruption as possible

Introduction

The mummified animal, IA1.2402, is held by the Australian Institute of Archaeology (the Institute) where it features in educational programs as a mummified cat known by students as *Charlie* (Figure 1). The scientific journey described in this paper aimed to uncover the story of *Charlie*, which was largely obscure. Its identity as a cat was uncertain and its history and purpose unknown. The research program was carried out by the author to satisfy the requirements of a Master of Research at Macquarie University with oversight from the Australian Nuclear Science and Technology Organisation (ANSTO) and the results were published in the scientific journal *Archaeometry* (Raymond et al 2019). This paper summarises those results and discusses some of their broader implications.

Animals were revered by ancient Egyptians because they were seen to be manifestations of or representatives of the gods and sometimes oracles for them. Ibises, for example, connected to the god Thoth, canines to the god Anubis and cats to the goddess Bastet. Cats were an integral part of ancient Egyptian domestic life from the predynastic times, acting as protectors of stored food from rodents and snakes. The goddess Bastet was also connected to lionesses and the goddess Sakhmet until the 22nd Dynasty (943–716 BC) and symbolised protection, beauty, fertility and sexuality (Linseele et al 2007; Remler 2010; Kurushima et al 2012; Bleiberg et al 2013). Bastet was worshipped in the temple at the delta city of Bubastis and honoured at the necropolis of Saqqara where many thousands of mummified cats were buried and where Sakhmet was the consort of Ptah the principal god of nearby Memphis and an important goddess in her own right (Ejsmond & Przewlocki 2014: 245; Zivie & Lichtenberg 2015: 108).

Figure 1: *The mummified animal IA1.2402, 21.3 x 4.8 x 7.8 cm. Photo: the Institute.*

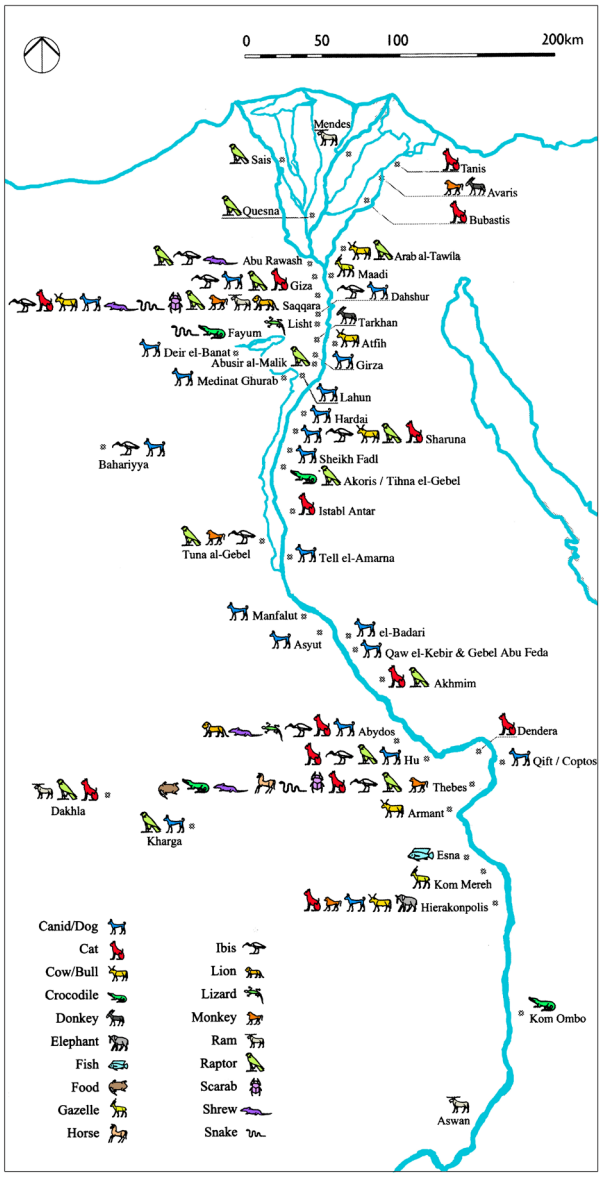

Figure 2: *Map of Egypt showing a spread of animal cemeteries. Drawing: adapted from Ikram (2015: xv) originally drawn by Nicholas Warner.*

The ancient Egyptians were prolific in their practice of animal mummification, as seen from the millions of mummies found in multiple animal cemeteries in Upper and Lower Egypt (Figure 2). The mummification of animals began in the Old Kingdom Period (2649 – 2150 BC) and continued until the beginning of the Islamic Period (AD 642) (Harrell & Lewan 2002; Maurer et al 2002; Ikram 2015). Changes in wrapping design and style occurred during this time.

When introducing a recent volume on animal mummies, Ikram identifies four reasons for the practice of animal mummification: beloved pets buried with their owners; victual mummies as funerary food offerings for the dead; sacred animals that were worshipped when alive and; votive offerings (2015: 1). The context is important when assessing the meaning of the animal mummy categories. The first two mummified animal burial types are commonly associated with human burials, while the last two are found in animal cemeteries generally associated with temples. Ikram defines a votive offering as a mummified animal 'dedicated to its corresponding divinity so that the donor's prayers would be addressed to the god throughout eternity' (2015: 9). She likens the practice to worshippers who burn candles in church. Documentary evidence for the practice of votive offering in ancient Egypt is found in John Ray's *Archive of Hor* (1976; Bleiberg et al 2013: 91-7). The archive contains documents written by Hor, who was a scribe at the sacred animal temple complex at North Saqqara.

At the large animal cemetery of Tuna el-Gebel, Kessler distinguished between two different kinds of mummified animals based on their style of wrapping: votive animals that were deliberately killed for ritual purposes, and sacred animals that died from natural causes within sacred temple precincts (2015: 155). However, it is recognised that by far the greatest number of mummified animal burials were votive offerings that were made from remains of animals that were intentionally bred and killed for the purpose of mummification (Armitage & Clutton-Brock 1981; Ikram 2009; Hartley et al 2011; Petaros et al 2015; Plessis et al 2015; Nicholson et al 2015: 647). Evidence of this can be seen in cat breeding grounds (Armitage & Clutton-Brock 1981; Malek 1993: 96; Zivie & Lichtenberg 2015: 118) and several cemeteries that had catacombs for mummified cats, namely Bubastis, Tanis, Mostagedda, Hierakonpolis, Saqqara, Abydos and Speos Artemidos near Beni Hassan (Malek 1993: 96; Ejsmond & Przewlocki 2014: 245; Zivie & Lichtenberg 2015: 108). From these sites, many examples of votive mummified cats have been found, displaying a wide variety of wrapping styles and decorations (Figure 3).

Votive offerings were purchased by pilgrims and citizens and were dedicated at the temple as gifts for the gods in exchange for particular blessings such as health, protection or prosperity (Bleiberg et al 2013; Plessis et al 2015), or to request something particular from them in this life or the afterlife (Wasef et al 2015; Nicholson et al 2015).

The Accession Story

The Institute has documentation for most of its collection but there is nothing referring to a mummified animal. David Searle, the curator of the collection in 1969, confirmed its presence in the collection at that time but there was no knowledge of its accession path (per. comm. C.J. Davey).

In 1950 James Stewart, the Assistant Curator of the Nicholson Museum, The University of Sydney, arranged for transfer of an embalmed head to the Institute (AIA doc. 393). Between 1938 and 1954 several other objects were exchanged between the Nicholson Museum and the Institute for which there is no documentation and it appears that the mummified cat may have been amongst

Figure 3: *Variety of wrapping styles of mummified cats, from various periods. a) 37.1991Ea-c Third Intermediate period, (760 – 390 BC) unprovenanced 24.1 x 15.2 x 88.9 cm; b) 37.1988E Third Intermediate period (750 – 400 BC), unprovenanced 14 × 9.5 × 62.2 cm; c) X1179.3 Late Period (664 – 308 BC) unprovenanced 5.4 x 7.6 x 26.4 cm; d) 05.307 Graeco-Roman Period, unprovenanced (305 BC – 395 AD) 37.8 × 7 × 9.5 cm; e) EA6753 Roman period (post 30BC), Thebes EA37348 Roman period, Abydos 53 cm long; f) EA37348 Roman period, Abydos, 46 cm long. Images from the Brooklyn and British Museum collections;* a. *www.brooklynmuseum.org/opencollection/objects/118492,* b. *www.brooklynmuseum.org/opencollection/objects/4197,* c. *www.brooklynmuseum.org/opencollection/objects/179037,* d. *www.brooklynmuseum.org/opencollection/objects/17360,* e. *www.britishmuseum.org/research/collection_online/collection_object_details.aspx?objectId=117351&partId=1&searchText=cat+mummy&page=1* f. *www.britishmuseum.org/research/collection_online/collection_object_details.aspx?objectId=117617&partId=1&searchText=cat+mummy&page=1.*

them. A mummified cat is included as item No. 30 in the 1891 catalogue of the Nicholson Museum, *Ægyptiaca* (Nicholson 1891). Artefacts and materials that appear in this catalogue were acquired by Sir Charles Nicholson between 1856-7 on an expedition to Egypt. When visiting Saqqara, Nicholson acquired several animal mummies, so it is possible that the IA1.2402 was one of them (Sowada 2006: 4).

Object Description

The mummy is a total height of 21.3 cm from base to tip of the ears (white dashed line on Figure 4). Across the broadest section of the specimen, the width measures 4.8 cm, and the breadth, 7.8 cm (orange line on Figure 4). The outside of the wrapping is in overall good condition and is made to appear as a small cat. The general shape is an irregular cylinder, with a column-like 'body' and a small rhomboidal 'head' on top. The left side of the specimen appears to be in good condition, as most of the textile is still well secured. The right side is in good-to-poor condition, with a few loose ends of textile near the base of the specimen, and a small worn area just below the band markings. While the mummified specimen has been protected in the box, the right side has been the reverse and is rarely seen. There is a considerable opening in the base of the body, where the textile is mildly frayed. The opening appears to have been deliberately made and is not the result of wear. The remains are partially

Figure 4: *Diagram of measurements.*

visible through the opening with blackened, dry skin, hair follicles and reddish-yellow to red-brown fur clumped together with remnants of organic residue.

Figure 5: *Images and drawings of the decoration on IA1.2402.*

There are painted, albeit crude, decorations covering the entire object mimicking a cat's collar, anatomy, tail and pelage. On the 'head' there are two red circles with black dots in the centre for eyes. Around the narrow section between the 'head' and 'body' are two coloured bands, one green and one red. The painted features on the rest of the specimen are depicted in both green and red pigments. The first set of markings from the top are chevron shaped, pointing downwards, while the lower markings are also chevron shaped, pointing upwards. It appears that the red paint has been applied after the green, as it overlays the green in places. On the rear, there is a long red straight line which curls over to the right at the midpoint of the back. Beside the red is also a straight green line, which does not curl over to the right. Below these lines is a single, red spot. A sketch of these markings can be seen in Figure 5. An extensive search indicates that this type of colourful painted markings was not common at Saqqara (Zivie & Lichtenberg 2015: 117).

The linen bandages spiral down from the narrow section below the 'head' towards the base. The end of the bandage is wrapped around the bottom of the specimen, coming back up on an angle and secured with a brown substance. There are no patches, or signs of stitching or mending. The textile itself is a plain, coarse weave without selvedges. The weave is loose, with S-spun individual threads, some more tightly wound than others.

Research Aims

The initial aim of the research was to confirm the artefact's authenticity using radiocarbon dating. Its unusual appearance and lack of provenance made this essential. A second important aim was to define the contents of the mummy and identify any animal remains. A third objective was to investigate the mummification techniques using 3D imaging to distinguish layers and style. This study was dependent on the use of non-destructive methods including NCT and X-ray CT from both medical and synchrotron sources.

Methods of Analysis

Two 3D imaging techniques were chosen for this study, X-ray CT and NCT. X-ray CT has been widely applied to mummy research in the last 50 years (Harwood-Nash 1979; Isherwood et al 1979; Raven & Taconis 2005; Adams 2015; Adams et al 2015; McKnight 2015; Bewes et al 2016). NCT is a relatively new technique in archaeological studies, as it is harder to access nuclear facilities and it can be expensive. With the construction of the OPAL nuclear research reactor and associated neutron imaging instrument 'DINGO' at ANSTO, there has been greater accessibility to NCT through merit-based access in Australia, enabling variety of metallurgical studies in the last few years, for example on swords, and coins (Salvemini et al 2014; Olsen et al 2015; Salvemini et al 2016), and increasingly in palaeontology (Mays et al 2017; Bevitt 2018; Gee et al 2019). However the application of NCT to mummified remains has been much less explored (Salvemini et al 2016; Raymond et al 2019).

Both NCT and X-ray CT methods are used to achieve three-dimensional images of the internal features and contents of objects. In each case, a beam of radiation (neutrons or X-rays, respectively) is passed through an object and the shadow image is captured as a radiograph behind the object. By capturing hundreds of thousands of radiographs as the object is being rotated, computational algorithms can be used to convert these two-dimensional images into three-dimensional reconstructions. The fundamental difference in interaction between these forms of radiation, and atoms within materials, yields different views and insights into the object being studied. Specifically, while X-rays interact with the electrons surrounding each atom and are highly attenuated by dense materials, they pass straight through soft tissue and can be used to image materials such as bone and metal in medical applications. Neutrons, however, interact with and are scattered by atomic nuclei of materials, resulting in different absorptions and interactions in the material. For example, neutrons can pass through steel and lead, but are highly attenuated by hydrogen atoms, thus are effective in showing organic materials even when encased within metallic objects. It was therefore hypothesised that

Figure 6: *X-ray (left) and Neutron (right) images. A. Wrapping direction and markings; B Sagittal slice; C. Coronal slice; D. Transverse slice near the paws showing the highly attenuating object only seen in X-ray data. Adapted from Raymond et al (2019).*

using a combination of the two techniques would provide a more complete view of the contents of the mummy, including any bones present, the wrapping layers and any amulets that may be inside.

X-ray CT scans were undertaken by Prof. John Magnussen at Macquarie Medical Imaging, Macquarie University Hospital. NCT scans were undertaken at the ANSTO, by Dr Joseph Bevitt and Ms Carla Raymond, on the DINGO beamline. The parameters of these experiments can be found in Raymond et al (2019).

Radiocarbon dating and pigment analysis both required small samples to be removed from the mummy. The samples were collected from discrete areas that would not affect the appearance or structural integrity of the artefact. One sample of skin and fur was taken from inside the wrappings through the opening in the base. Another two samples were taken from the outer wrapping, one with green pigment on it, and the other two loose threads from the base at the opening. A final sample was collected from the box in which the cat usually resides, as it had some red pigment on it and so there was no need to remove further samples for pigment analysis. Samples of the wrapping, the skin and fur were sent to Beta Analytic Inc. in Florida for radiocarbon dating. This is a lengthy process of removing organic acids, reducing the remaining material to 100% graphite, and passing it through an Accelerator Mass Spectrometer (AMS).

Summary of Results

The X-ray scan shows the painted markings clearly in the bright areas on the outer wrapping in Figure 6A, while the neutron data does not show the paint at all. The benefit of using NCT however is that it shows the textile wrapping direction, which matches the visual observations where it wraps downward in a spiral fashion.

X-ray results of the internal features revealed a partial skeleton of a cat, including an articulated tail (23 vertebrae) and two hind legs with metatarsals (Figure 6B-C). There is no visible trace of a spine, ribcage, skull or fore-limbs. The textile layers were to some extent discernible, as there was a density contrast between the bandages closest to the skeleton and those further out. Additionally, the X-ray scans revealed a small (4 x 2 mm), highly attenuated object next to the paws which can be seen in Figure 6D. Because of its high absorption, it is likely to be a metallic object. It may be an amulet but, as it is amorphous in shape, it is difficult to identify. Higher resolution x-ray CT studies will be employed to identify this object. Interestingly, this metallic object was not initially observed in the neutron 3D digital reconstruction because of the low relative neutron attenuation of the constituent metal.

The reconstructed neutron data also showed the partial skeleton and it revealed coarseness and layering of the wrapping because of the higher attenuation of neutrons by the fabric and skin relative to X-rays (Figure 6B-C). The contrast between bones and textiles is not as clear as in the X-ray data, however it reveals much about mummification style and materials. The textile close to the skeleton is more tightly wrapped, and is a finer quality fabric, as the individual threads are smaller and closer together. The outer wrapping is much coarser and is wrapped more loosely, which correlates well with the density contrast seen in the X-ray data. The neutron data also revealed that the 'head' of the cat was actually a wad of fabric that had been folded to give the shape, which was not visible in the X-ray radiographs. A combination of both data sets helped to reveal not only the presence of bones but more details about the nature and quality of the textile. More comprehensive results are provided in Raymond et al (2019).

Radiocarbon dates revealed some unusual information about this mummy. The sample of the remains was re-categorised as 'plant material' by Beta Analytic, as there was apparently a large amount of plant material present. Following the AMS dating process, the mummified remains, mixed with plant material gave a date of 2690 ± 30 BP (before present). This would place the skeleton between 900 – 804 BC (Third Intermediate Period) to 95.4% probability. The external wrapping sample dated to 2230 ± 30 BP or 367-204 BC, placing it between the Late Period and Ptolemaic Period. Therefore, there is a difference of approximately 500 years between the skeletal remains and the wrapping. Another check sample is being secured for dating as is standard practice.

Discussion

The novelty of this study is two-fold. It is the first of its kind to apply NCT to the study of mummified Egyptian remains and also the first to employ both neutron and X-ray CT in a multi-modal imaging study of the same mummified animal. It thus serves as a comparative study of the individual techniques. A combination of the two data sets has yielded unprecedented insights into this mummy, shown the undisturbed skeletal remains in relation to the wrapping style and the textile quality. This allowed for comparison with the accounts of Ginsburg (1999), where he unwrapped several cat mummies from the Bubasteion at Saqqara. Ginsburg described the outer layers of wrapping as coarse and loose, distinguishing them from an inert set of finer and tighter wrappings directly surrounding the remains. He noted that larger cat mummies had up to three layers of wrapping, however smaller ones only exhibited two layers of wrapping. The combined use of both X-ray CT and NCT as a multi-mode imaging methodology has achieved enhanced contrast based on simultaneous, dual-segmentation of individual components of these remains using a two-dimensional matrix of neutron and X-ray attenuation values.

A close study of the skeletal remains revealed that the animal inside the wrappings was a small feline. This was determined with the help of zoo-archaeologist, Dr Tyr Fothergill, who identified that there were 23 caudal vertebrae in the tail, a feature of felid skeletons. Additionally, Dr Tyr Fothergill identified from the growth plates that this cat would have been approximately 11 months of age at death. The species of cat was difficult to determine, as typically this is determined by shape of skull or pelvis. In the absence of these bones, analysis of the calcaneus can also give information about about the species. According to the study by Van Neer et al (2014) regarding the shape of the calcaneus, this cat can be classified as *Felis silvestris* (Figure 7), an ancestor to the domestic cat. There are insufficient skeletal remains to determine if an injury was inflicted to either the spine or skull therefore the cause of death is indeterminate.

Radiocarbon dates of the internal contents and external wrapping revealed a 500-year difference between the two samples. The difference prompts discussion about the concept of recycling and re-wrapping of votive offerings. The most plausible suggestion for this age gap is that the original remains were mummified in the Third Intermediate Period and deposited in a catacomb or cemetery. After 500 years, with increased demand that could not be met by breeding facilities, this mummy was removed from its resting place, re-wrapped and re-sold. It is uncertain if the unique painted markings were added at this time or later.

New questions arise from this conclusion however. Did this mummy always contain a partial skeleton, or was the original mummy a complete skeleton that was separated 500 years later? The partiality of the remains is not unusual in mummified votives As mentioned

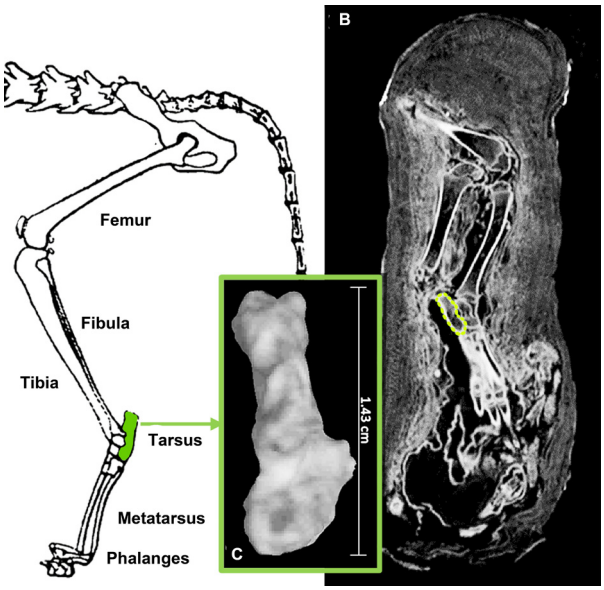

Figure 7: *Skeleton of the hind quarters of a cat with calcaneus highlighted (Adapted from Jayne 1898); B. X-ray slice showing calcaneus of IA.2402 and C. a 3D reconstruction of it.*

previously, it was quite common for mummy bundles to contain mixed selections of bones or sticks and mud. There are no visible fractures or breaks on the fibula or tibiae, nor the metatarsals. The tail is dis-articulated in three places (Figure 8), which may have occurred because of handling during the re-wrapping process or over time due to desiccation and fragility. It is expected that after centuries of decay, any substantial manipulation of the bones and remains would result in some breakages. The intact nature of the tip of the fragile tail suggests that this mummy has had minimal interference in the re-wrapping process and may have only ever contained these partial remains.

The origin of the mummy remains uncertain and its decorated appearance is unlike others in published reports. Other features such as the spiral wrapping pattern and the false ears, resemble a few examples from the Brooklyn Museum, Walters Art Museum, Baltimore, and the Nicholson Museum. Unfortunately, these artefacts also lack provenance information in the online databases. The wrapping style of two distinct layers of different textiles corresponds to the work of Ginsburg (1999) at Saqqara. It is therefore possible that this cat was from Saqqara, however, recent cat mummy finds at the Bubasteion in November 2018 did not resemble IA1.2402.

Future Research and Outcomes

A more detailed study of the pigments used to decorate the external wrappings is ongoing, involving a suite of geo-analytical techniques that is present at Macquarie University Geo-Analytical laboratories and ANSTO, namely Scanning Electron Microscopy, Raman Spectroscopy, X-ray Diffraction and Neutron Activation Analysis. It is anticipated that once the pigments have

Figure 8: A 3D reconstruction of the partially articulated tail. The 23 caudal vertebrae are denoted in red, and the blue dashed lines indicate breaks.

been characterised, their antiquity may be confirmed and their origin identified.

The successful analysis of *Charlie* has led to the need for comparative data from other animal mummies. Access is now being sought to other animal mummies in collections in Australia and overseas to undertake similar research.

The outcomes of this project contributed to a successful Telematics Trust grant proposal, *Revealing Mummies: The Inside Story* by the Institute. This funding will enable the research team to make the details and results of this research program available to students using visual and digital platforms. A short documentary will be produced that summarises the research process and findings. Interactive 3D reconstructions of the IA1.2402 will assist students to explore the nature of the mummy and there will be files for 3D printing and accompanying educations resources for these multimedia outputs. These outputs will serve the aim of broadening the accessibility of these important cultural resources for education and remote communities.

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