

**Institution: The University of Edinburgh**

**Unit of Assessment: 17 Archaeology**

**Title of case study: Uncovering the secrets of the Rhind Mummy (in partnership with National Museums Scotland)**

### 1. Summary of the impact

Research on medical imaging, undertaken by Kranioti at the University of Edinburgh since 2010, has led to cultural, commercial and practice-based impacts.

- i) Collaboration with National Museums Scotland (NMS) on the successful *Fascinating Mummies* exhibition (2012) involved the construction of an in-depth virtual view of a specific popular exhibit – the Rhind Mummy excavated in 1857 (5.3). The initial exhibition attracted 61k visitors, and provided enhanced public understanding of these important artefacts and material about the virtual view continues to be available online.
- ii) Collaboration with the Hologica company to combine computerised tomography (CT) scanning technology with photonics technology in order to produce an innovative digital hologram product based on the Rhind Mummy's skull giving a true 3D view of the object. This has subsequently been displayed at the Holography Museum at MIT, Cambridge, MA.

Radiologists and police in Scotland have separately sought Kranioti's expertise to improve their understanding of the values of medical imaging technology in cognate fields of forensic anthropology.

### 2. Underpinning research

The underpinning research concerned the application of virtual tools and medical imaging technology to the reconstruction of an individual's biological profile and the circumstances surrounding their life and death.

In her work since joining Edinburgh Archaeology in early 2010, Kranioti has enhanced the understanding of the application of new technologies within the field of forensic and physical anthropology; these form the basis for her pioneering research on virtual anthropology, geometric-morphometric methods and skeletal trauma. Her approaches utilise a range of software including *TPS Series*, *Morphologika*, *Amira*, *Morpheus et al.* and *ViewBox*.

Of special significance for her contribution to the Rhind Mummy project was the virtual study of Cioclovina, an early *Homo sapiens* fossil from Romania, in collaboration with K. Harvati (University of Tübingen) and R. Holloway (Columbia University) (3.1). In this earlier project, her research focused on the virtual study of the endocast; and this aspect of her research was profiled as the cover story in the *Anatomical Record*.

Kranioti's interest in cranial trauma has also resulted in a project in collaboration with Edinburgh University's Clinical Research and Imaging Centre (CRIC – team led by E.J.R van Beek – Professor at UoE since 2009) and the Department of Radiology, University of Crete. This dealt with the assessment of peri- and post-mortem cranial trauma through Computerised Tomography (CT) scans (3.2). A more recent achievement was the development of a virtual age-independent sex estimation method based on measurements of the bony labyrinth of modern skulls (3.3).

In a related project, also using CT scans and the Amira 5.4 modelling software and funded by the College of Humanities and Social Science Challenge Investment Fund, Kranioti worked with Samantha Donnellan (UoE Research Assistant 2012-2013) to study the effects of injuries inflicted on the craniums of pigs by sharp and pointed objects in an attempt to match the cut marks on the bone to the assaulting weapon(s) and to design a method which can be utilized by forensic anthropologists to assist the legal authorities in the rapid identification of weapons by the unique cut marks left by such weapons in bone (the Sharp Force Trauma study) (3.5).

On the basis of her wide experience in the applications of medical imaging derived from CT scan technology Kranioti was able successfully to collaborate with NMS and to provide an exciting and informative display of the *Secrets of the Rhind Mummy*.

Kranioti's contributions to the Rhind Mummy project were to provide biological profiling and

interpretation of the CT scans using 3D visual tools. Her involvement ensured a thorough virtual examination of the remaining soft tissue, the skeleton and the interior of the sarcophagus, which thus also offered a first-class opportunity for visitors to the museum to have a visual representation of the individual under the wrappings without physical disturbance to the mummy. To achieve these results required the manual segmentation of the skeleton, soft tissue and artefacts inside the coffin, followed by their 3D reconstruction using advanced imaging software. This provided an accurate model for the face and cranium.

### 3. References to the research

3.1 E.F. Kranioti, R. Holloway, S. Senck, T.Tudor Ciprut, D. Grigorescu & K. Harvati 2011 'A virtual assessment of the endocranial morphology of the early modern European fossil calvarium from Cioclovina, Romania'. *Anat Rec* (Hoboken) 294 (7), 1083-92. In REF2

3.2 D. Fleming-Farrell, K. Michailidis, A. Karantanas, N. Roberts & E.F. Kranioti 2013 'Virtual assessment of perimortem and postmortem blunt force cranial trauma', *Forensic Sci Int* 229,1-3: 162.e1-162.e6. [DOI 10.1016/j.forsciint.2013.03.032](https://doi.org/10.1016/j.forsciint.2013.03.032)

3.3 B. Osipov, K. Harvati, D. Nathana, K. Spanakis, A. Karantanas & E. F. Kranioti 2013 'Sexual dimorphism of the bony labyrinth: A new age-independent method', *Amer Journ Phys Anthropol* 151 (2). In REF2

3.4 E. F. Kranioti, T. Ciprut, D. Grigorescu & K. Harvati 2011 'The bony labyrinth of Cioclovina, an early modern European from Romania', *Amer Journ Phys Anthropol* 144: S52:191-2 (published abstract) [DOI 10.1002/\(ISSN\)1096-8644](https://doi.org/10.1002/(ISSN)1096-8644)

3.5 S. Donnellan, F. Chatzinikolaou, & E. F. Kranioti 2012 'Morphological Analysis of Sharp Force Trauma Patterns Using High Resolution Casts', *Internat Journ Legal Med* 126 (Suppl 1): S175-6. [DOI 10.1007/s00414-012-0711-9](https://doi.org/10.1007/s00414-012-0711-9)

For her workshop and study of 'Morphological and Historical Analysis of Sharp Force Trauma Patterns using High Resolution Casts and Virtual Tools', Kranioti received a College of Humanities and Social Science Challenge Investment Fund award of £9969.

### 4. Details of the impact

Kranioti's research has made an important contribution to the public understanding of ancient Egyptian culture and life as part of the NMS exhibition, with significant impact demonstrated through media coverage and documented visitor responses (5.1). In addition, as a result of its translation, via a combination of visual imaging technologies with photonics technologies, into a product sold by a start-up photonics engineering company based in Edinburgh (Holoxica), it has also had significant impacts in the commercial sphere because of the new opportunities it has opened up for Holoxica to develop innovative new products based on medical imaging and complex datasets.

Although the Rhind Mummy had been examined 15 years ago using CT, this was a pre-digital procedure. The recent Rhind Mummy project involved a team from CRIC, Edinburgh University, led by van Beek, using a CT scanner to re-examine the Mummy. Using their data, Kranioti was able to produce biomedical imaging of the skeletal remains within the unwrapped mummy which provided new images for the exhibition display, and enabled her to advance new insights into this individual's life and death. As part of *The Fascinating Mummies* exhibit, this display provided the key impact from this research. During the exhibition, between February and May 2012, 61,170 people visited the display (corroboration via NMS Press Office 5.6). Two videos (5.3) featuring the imagery made new information on the mummified individual and the associated artefacts inside their wrappings accessible; thus by the application of modern image technology it was possible to provide a new dimension to the exhibition which appealed to adults and children alike. The videos and display together demonstrated the exceptional insights into the lives, diseases, religious rituals and social structures of a past society that can be achieved through the application of these technologies to the Rhind Mummy.

Comments in the NMS visitor book (corroboration via NMS Press Office 5.6) attest the significance of the impact of this research and its application e.g. "Amazing interpretation, really clear and concise. X-ray films add a new dimension and show archaeology is now very much a

science not an art.”

- “Excellently designed exhibition which was logical and easy to follow. The section dealing with the advances of technology (x-rays and CT scans) was especially well done. It’s amazing how the collaboration of different disciplines can produce discoveries which have been lost for millennia without invasive techniques being used.”
- “Amazing. Very interesting and informative. Loved the process of the CT scans so we could actually see what the remains looked like. Great stuff.”
- “Modern technology meets Ancient Egypt. Fascinating.”

An indication of the reach of this research can be estimated from media interest arising from the exhibit. Illustrated articles in *The Independent* and *Scotland on Sunday* (14/1/2012; average circulation of 40,000 for that year) (5.2) included images of the skull and skeleton that the scans had revealed alongside the wrapped mummy; a detailed commentary on the findings included quotations from the project team.

Articles about the exhibition appeared on STV and in BBC *History* magazine websites (Historyextra.com) (5.1).

The video material created for the exhibition and made available on the web (5.3) received 2,494 plays in total. Kranioti’s forensic analysis in collaboration with the work of Van Beek’s CRIC team was featured on AuntMinnie.com and AuntMinnieEurope.com, (5.4), two highly respected online daily news publications for radiologists worldwide.

While the exhibition was running, Kranioti presented a public lecture and workshop on her 3D reconstruction of the Rhind Mummy based on medical imaging data as part of the Edinburgh International Science Festival 2012. Participation was limited to 50 and was sold out (5.6) The participants were enthusiastic and fascinated by the unfolding of the mummy’s secrets with the aid of modern imaging technology as evidenced from the numerous positive comments in the NMS visitor book (5.6).

An important measure of the reach of the research into the commercial sphere is the involvement with Holoxica (5.5a and 5.5b) an award-winning holographic imaging company using cutting edge photonics engineering technology, which is based in Edinburgh. Holoxica requested the 3D models of the Rhind skeleton for the purposes of creating a digital hologram. Kranioti was able to provide precise data to enhance the modelling of the face and cranium for use in this hologram. The hologram is animated revealing the mummy’s skull under the wrappings as one moves clockwise around it, thus giving a true 3D impression. The Rhind Mummy was selected from the hundreds of entries submitted in response to a call by the Massachusetts Institute of Technology, and has been on display during 2012-2013. The MIT museum is one of the largest Holography Museums in the world. Pursuant to an arrangement with NMS, which owns the rights to the images of the mummy, three copies of the hologram are available for purchase via the Holoxica website at a cost of £1,100 + VAT. The collaboration on the Rhind Mummy project with Kranioti has enabled Holoxica to move into the wider medical imaging arena with other museum pieces and commissioned work by the Anatomy Museum and the Royal College of Surgeons, Edinburgh, and the work led to Holoxica winning the Nexxus Scotland Collaboration Award in 2011 (corroboration via factual statement from Holoxica 5.9).

Following coverage of the Rhind Mummy results, Kranioti received invitations from the Scottish Radiology Society Junior Forum to address NHS Junior Doctors and Radiologists (Dundee) and the Edinburgh Radiology Society (both November 2012) on the value of Medical Imaging Technology in Forensic Anthropology. In addition she organised and delivered with colleagues a further KE event *Villains, Victims and Forensic Evidence*, which involved an audience of 80 that included the Friends of the National Museum of Scotland’ and featured a copy of the Rhind Mummy Hologram developed with Holoxica (5.7). This work also drew on the Sharp Force Trauma study.

It was because of the public prominence of her work, that Kranioti was also invited by the Forensic Unit of the Lothian and Borders Police (now Police Scotland) to present her associated sharp force trauma project and the potential wider applications of 3D scan technology in weapon

identification for assault or death cases following sharp force trauma. This presentation with Donnellan (June 2013), was linked by video conferencing with Police Forensic Departments in Glasgow, Dundee and Aberdeen. Approximately 100 scientific staff attended and were able to ask questions in real time on the work carried out by Dr Kranioti and her students. Feedback from staff was that the talk was illuminating and that further proposed work would be useful, perhaps in setting up an injuries database in Scotland (there is currently one based in England) (5.8).

### 5. Sources to corroborate the impact

Archived material is also available from tinyurl weblinks below.

5.1 Compilation of media sources on the exhibition:

<http://www.independent.co.uk/arts-entertainment/art/reviews/fascinating-mummies-national-museum-of-scotland-edinburgh-7440762.html> or [<http://tinyurl.com/ossvo4p>]

<http://www.edinburghspotlight.com/2012/02/news-fascinating-mummies-at-the-national-museum-of-scotland/> or [<http://tinyurl.com/nfij8ks>]

<http://www.scotsman.com/lifestyle/arts/visual-arts/visual-art-review-fascinating-mummies-national-museum-of-scotland-edinburgh-1-2118411> or [<http://tinyurl.com/oqhvgb7>]

<http://www.historyextra.com/mummies> or [<http://tinyurl.com/pfhspi3>]

<http://culturefreedomradio.webs.com/apps/blog/show/12461194-unwrapping-6-000-year-old-secrets-ct-scans-reveal-jewellery-stashed-in-bindings-of-egyptian-mummies> or [<http://tinyurl.com/pkbj8gy>]

<http://news.stv.tv/east-central/297120-egyptian-treasures-on-display-as-mummy-exhibition-opens-at-national-museum-of-scotland/> or [<http://tinyurl.com/ojgs7dp>]

5.2 Detailed article in *Scotland on Sunday*: <http://www.scotsman.com/scotland-on-sunday/scotland/scan-unwraps-mummy-s-secrets-1-2057068> or [<http://tinyurl.com/pbnlgh>]

5.3 NMS Webpage containing 6 minute video

[http://www.nms.ac.uk/our\\_museums/national\\_museum/past\\_exhibitions/fascinating\\_mummies/secrets\\_of\\_the\\_rhind\\_mummy.aspx](http://www.nms.ac.uk/our_museums/national_museum/past_exhibitions/fascinating_mummies/secrets_of_the_rhind_mummy.aspx) or [<http://tinyurl.com/nh9zfw>]

Indicator of current number of video views can be found at <http://vimeo.com/36691281> or [<http://tinyurl.com/pfl3ao2>]

5.4 <http://www.auntminnieeurope.com/index.aspx?sec=sup&sub=adv&pag=dis&ItemID=606473> or [<http://tinyurl.com/p79ajux>]

5.5a) Holoxica Rhind Mummy webpage: <http://www.holoxica.com/id/347> or [<http://tinyurl.com/nfuk2hp>]

5.5b) Photonics web-article about Rhind Mummy based hologram:

<http://www.photonics.com/Article.aspx?AID=50914> or [<http://tinyurl.com/nureecc>]

### People

5.6 Press Officer NMS for corroboration of visitor figures and other details for the exhibition

5.7 *Villains, Victims and Forensic Evidence*: Event details available on request from HEI

5.8 E-mail from SPA Forensic Services Edinburgh corroborating details of the meeting with Lothian and Borders Police and the video conferencing with Police Forensic Departments in Glasgow, Dundee and Aberdeen.

5.9 Email from Managing Director, Holoxica Ltd corroborating new opportunities following direct involvement in this project.