

THE THEBAN
NECROPOLIS
PRESERVATION
INITIATIVE

FACTUM FOUNDATION AND
THE UNIVERSITY OF BASEL
WORKING WITH
THE MINISTRY OF TOURISM
AND ANTIQUITIES

A REPORT ON THE WORK
COMPLETED IN
THE TOMB OF SETI I
UP TO SEPTEMBER 2020



Detail from the ceiling of the Sarcophagus Room in the tomb of Seti I, recorded in 2019.

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Under the patronage of



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This book is dedicated to the memory of Ayman Mohamed Ibrahim, the former inspector of the Valley of the Kings who understood the importance of the work of the Theban Necropolis Preservation Initiative and spoke about it with eloquence.

“The educational impact [of Factum’s digitisations and facsimiles] for the general public is indisputable: now scholars have to face the challenge of inserting these new tools into their research and exploiting their potential, before they are once more outwitted by commercial applications. The exhibition implicitly urges collaborations beyond the borders of museums and disciplines.”

Arnold Nesselrath

Review of the exhibition *Raffaello 1520-1483* at the Scuderie de Quirinale, Rome, in *The Art Newspaper*, July 2020

“Factum preserves evidence, neither reconstructing nor reformulating narratives.”

Katrina Kufer

Harper’s Bazaar Arabia, Autumn 2018

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A view of the restored Stoppelaëre House with a render of the proposed signage for the training centre.
Left page: Amany Hassan scanning above the niche in Chamber Jb.

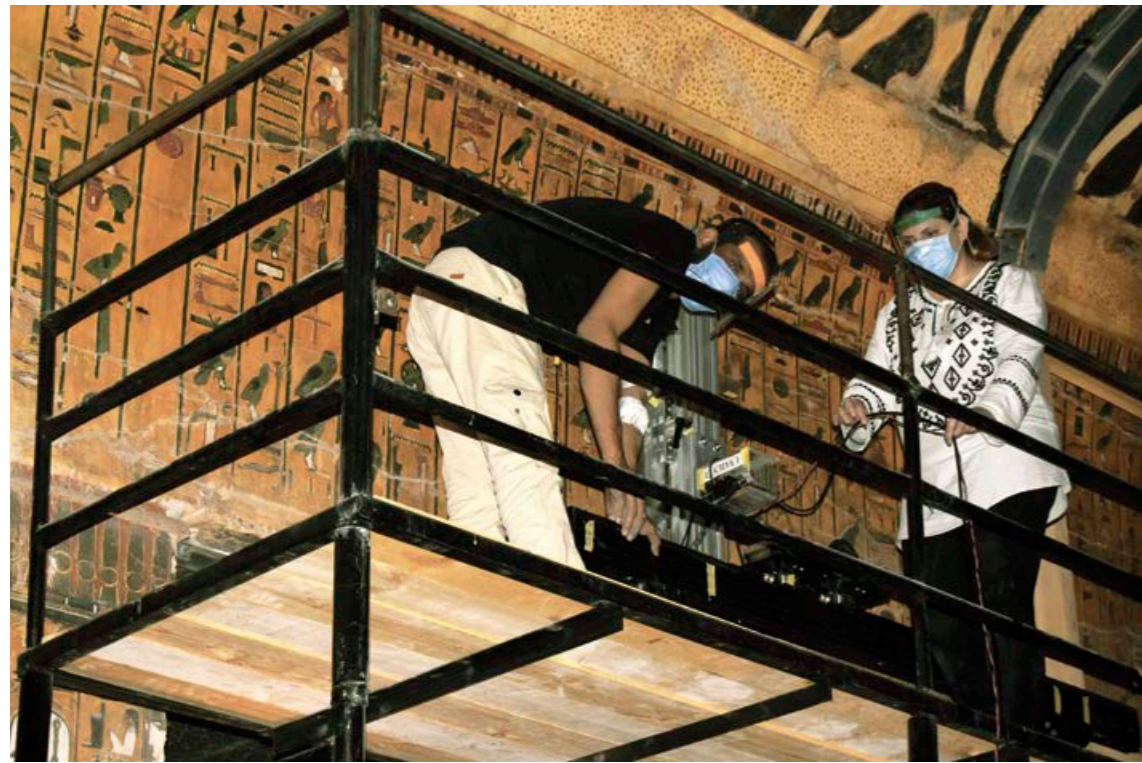
The Theban Necropolis Preservation Initiative (TNPI) is a collaboration between Factum Foundation for Digital Technology in Conservation and the University of Basel under the aegis of the Egyptian Ministry of Antiquities. Since 2016 the TNPI has worked to digitally document the tomb of Seti I, the largest and most important decorated tomb in the Theban Necropolis, at the highest resolution possible in 3D and colour. The initial recording work began in 2001 with a close-range laser scanner that has evolved over the years. Recording was also carried out in the burial chamber of Thutmosis III in 2002 and in Tutankhamun's burial chamber in 2009 and again in 2019. The data is being used for both online and offline applications. Online it is being used for study, condition monitoring, sharing and communicating the importance of pharaonic culture. Offline it can be rematerialised at 1:1 as an exact facsimile that is indistinguishable from the original to the naked eye under normal lighting and viewing conditions.

On 14th November 2012 Baroness Ashton, the EU High Representative, said the following words on the occasion of the donation of Factum's facsimile of the Tomb of Tutankhamun to Egypt:

'The gift of the facsimile is a metaphor for the relationship between Europe and Egypt - the skills and technology that have been developed in Europe to create the facsimile are going to be transferred to Egypt where the local workers will be trained and those very skills and technology will become Egyptian.'

Since the start of 2019 the work of the TNPI has been carried out by a totally Egyptian team working with Factum Foundation. One of the main goals of the TNPI since the beginning has been to ensure that the local community benefits from internationally funded efforts to preserve cultural heritage. The fact that the training is proving effective, with an Egyptian team now carrying out all operations on the ground, is an example of successful capacity building. Over the

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Scanning in the Sarcophagus Room in the Tomb of Seti I following the partial lifting of restrictions due to COVID-19, July 2020.



Members of the team return to the tomb after the partial lifting of restrictions in Egypt.

past year, the Luxor team has grown to include six local people in addition to Aliaa Ismail, the director of the TNPI's Centre for Scanning, Training and Archiving. It is proposed that four more will be trained over the coming 24 months.

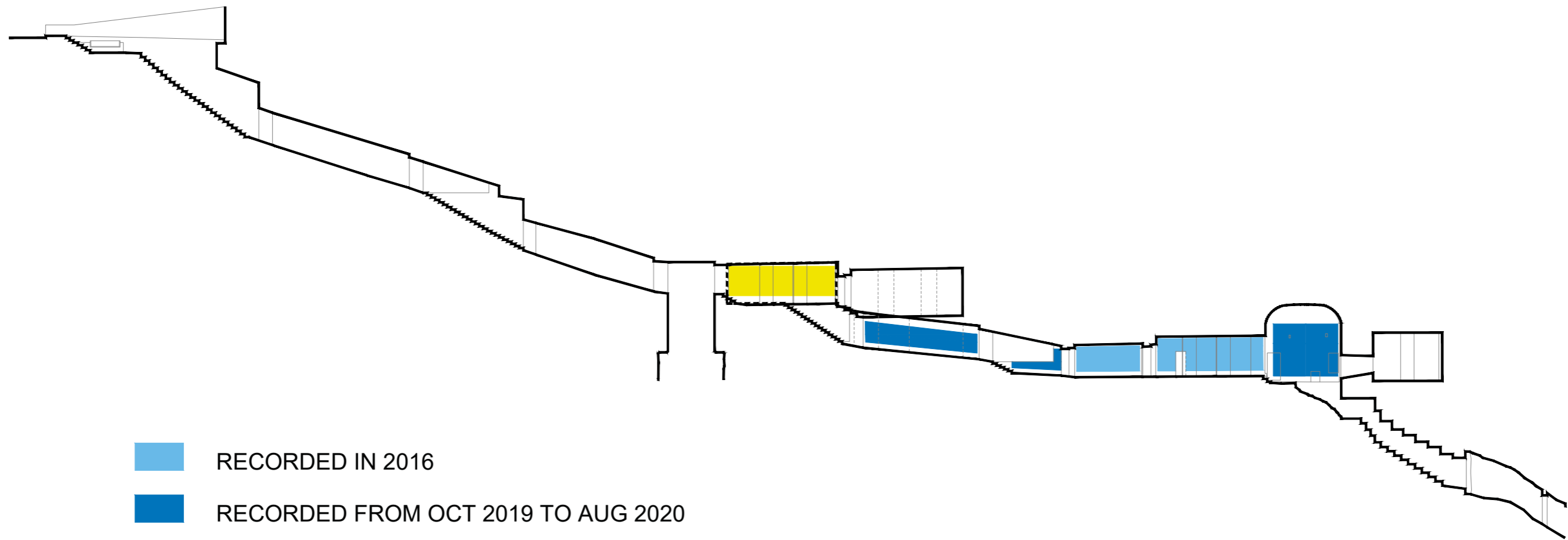
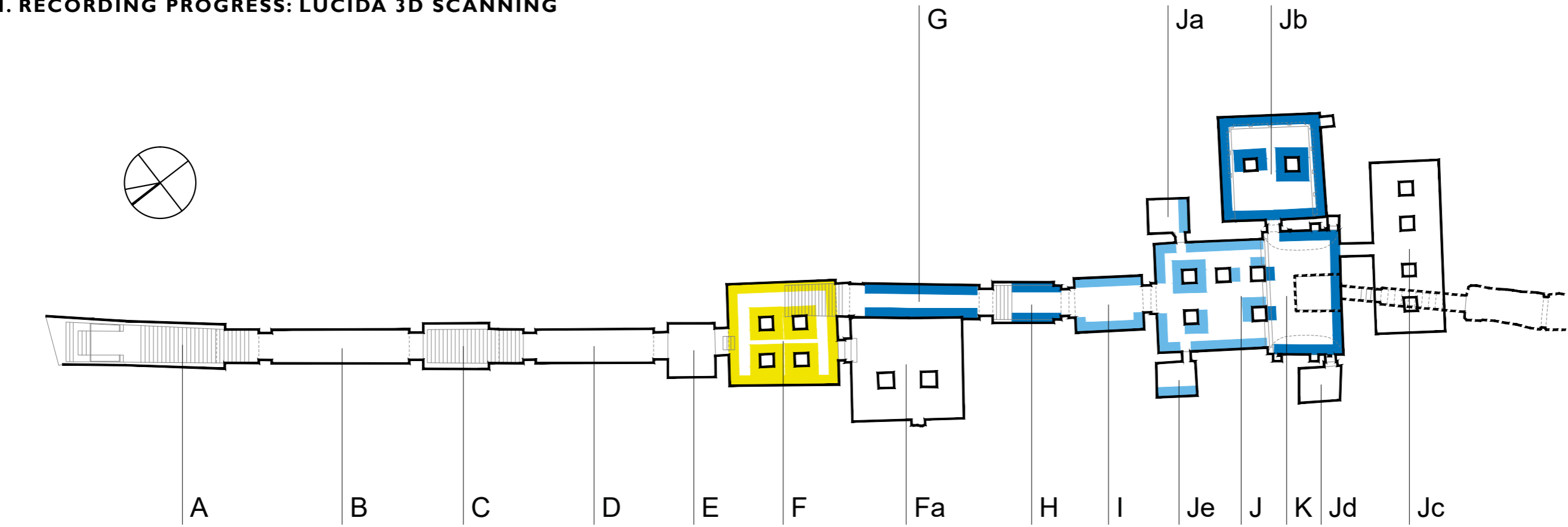
Stoppelaëre House, a prominent building at the entrance to the Valley of the Kings designed by Hassan Fathy and restored by Factum Foundation and Tarek Waly in 2016-17, is the base from which all work is co-ordinated and all training carried out. The building also serves as the temporary archive while the data is being processed and before it is given to the Ministry. The 3D Scanning, Training and Archiving Centre still needs to have a reliable water supply installed and to secure better internet access, but it has already been vital in the success of the TNPI's work. Assistance from Factum Foundation's Madrid team has been limited to sending money, remote support and troubleshooting. Factum's involvement is focussed on improving the speed and quality of the work, maintaining the equipment, checking the 3D data online, providing online training/support and upgrading the equipment. Members of Factum's core team travel to Luxor to continue training, maintaining equipment and ensuring that new innovations are passed on to the TNPI team.

The Coronavirus pandemic has restricted work since April, but in line with Egyptian regulations, a reduced workforce was able to return to the tomb of Seti in July. TNPI was the first team to resume work in the Valley of the Kings. In many ways, the crisis has also underlined the importance of the work being carried out by the TNPI: 2020 has seen a new global recognition of the importance of digital recording for documenting and displaying cultural heritage. At the start of the COVID-19 shutdown institutions and cultural organisations were forced unexpectedly to move all audience engagement online. It suddenly became clear that – with almost no exceptions – museums large and small alike were lacking the digital assets required for a meaningful online presence. With international travel severely restricted for the foreseeable future, there is suddenly a pressing need for high-resolution data which is accessible in innovative forms and which can be used by many different audiences, from specialised scholars to the curious looking for something interesting to attract their attention. 2020 saw the launch of the 3D model of the Tomb of Seti I, which brings together a complete model of the tomb interior with the high-resolution recordings in colour and 3D of both the walls of the tomb and fragments removed at different times. There is a visceral and functional difference between this form of high-resolution 3D display and those recorded at the lower resolutions which are more commonly found online but seldom satisfying, engaging or meaningful.

The past year also saw the start of the recording of the fragments gathered together by the University of Basel and currently stored in the tomb of Ramesses X. Both the recording of the fragments and the development of the 3D online model will be an important part of the work of TNPI in the year ahead.

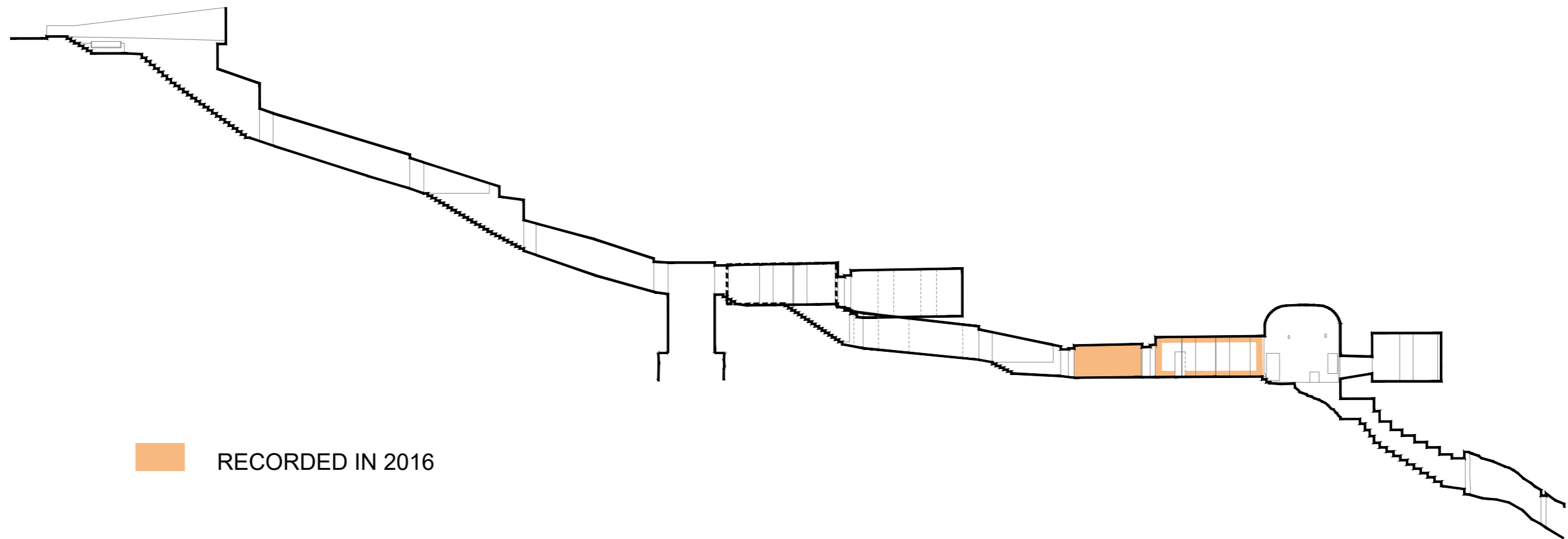
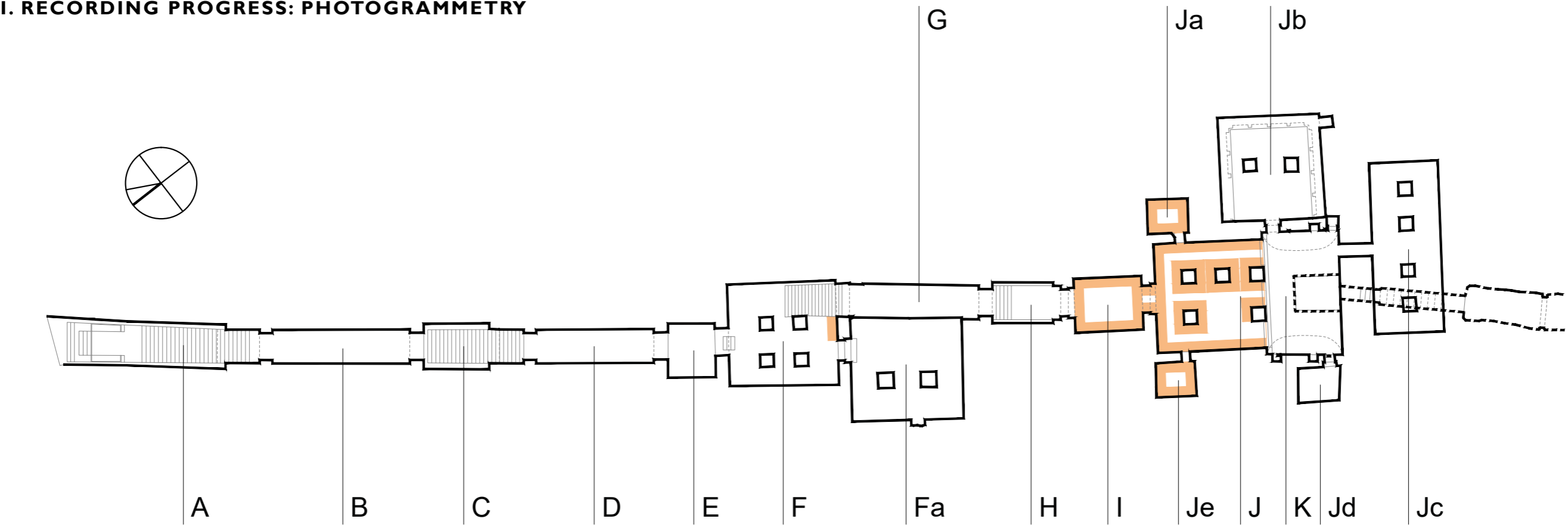
The TNPI is at a crucial point in its trajectory. It is setting standards both within the global field of high-resolution heritage recording and in local capacity building. In a year of bad news for cultural heritage institutions worldwide, it is creating recordings which have been viewed across the world. It has brought a positive message of international collaboration and local empowerment. With the correct level of financial input, the coming years will see the cementing of this pioneering initiative as a vital force for progressive, responsible conservation within the Valley of the Kings and hopefully elsewhere in Egypt.

SETI I. RECORDING PROGRESS: LUCIDA 3D SCANNING



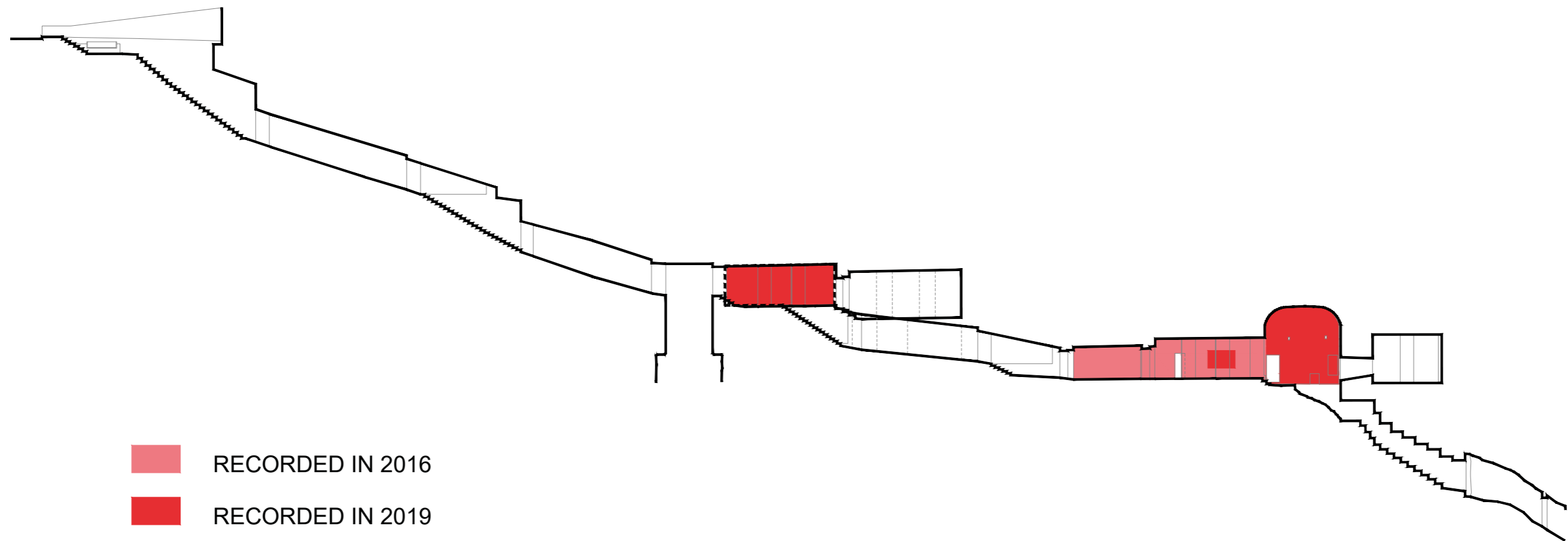
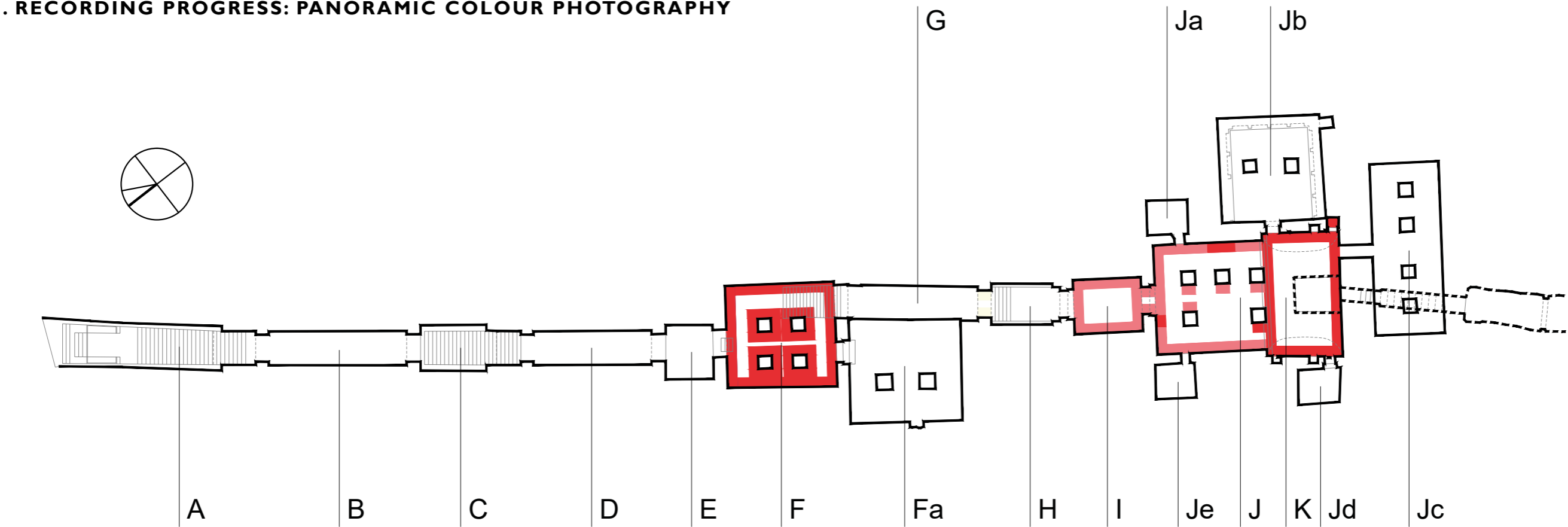
- RECORDED IN 2016
- RECORDED FROM OCT 2019 TO AUG 2020
- IN PROGRESS SEPT 2020

SETI I. RECORDING PROGRESS: PHOTOGRAMMETRY



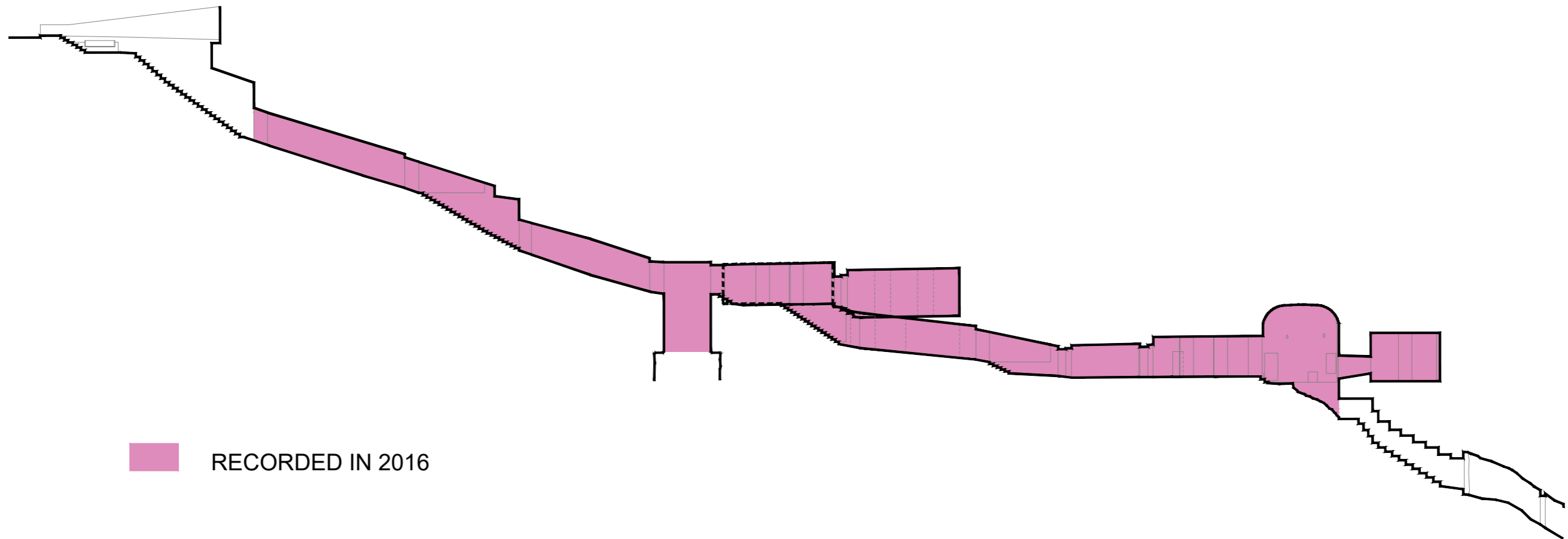
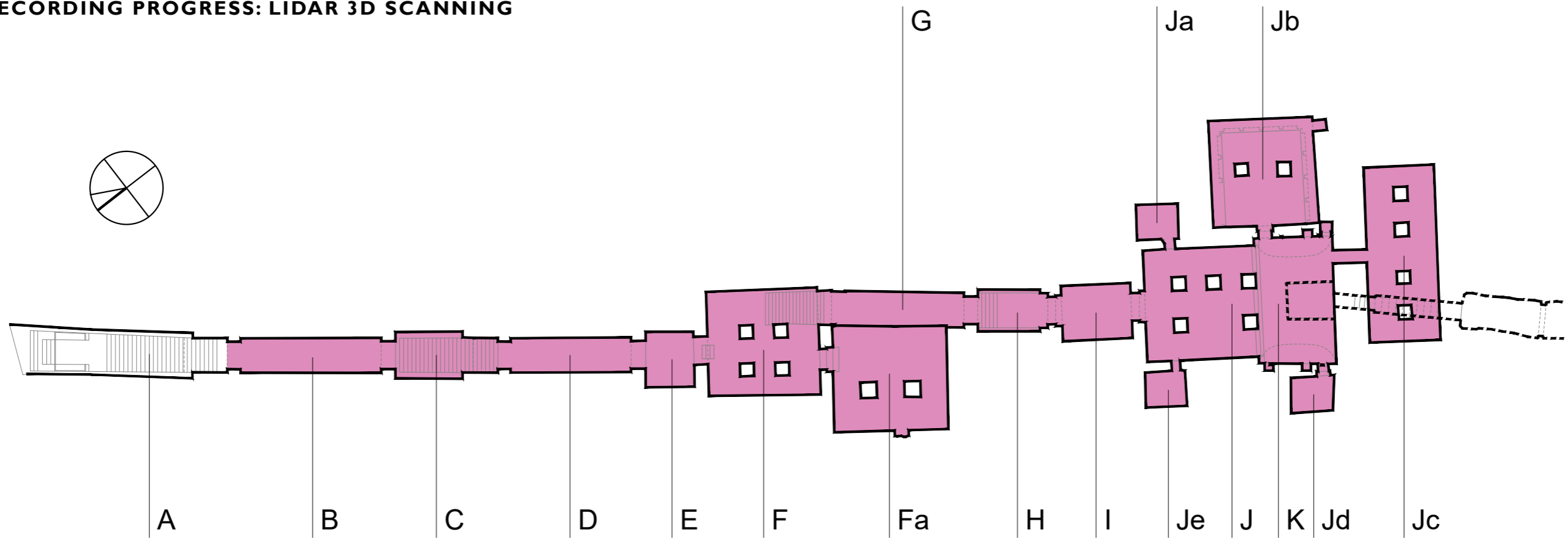
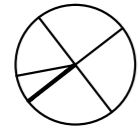
RECORDED IN 2016

SETI I. RECORDING PROGRESS: PANORAMIC COLOUR PHOTOGRAPHY



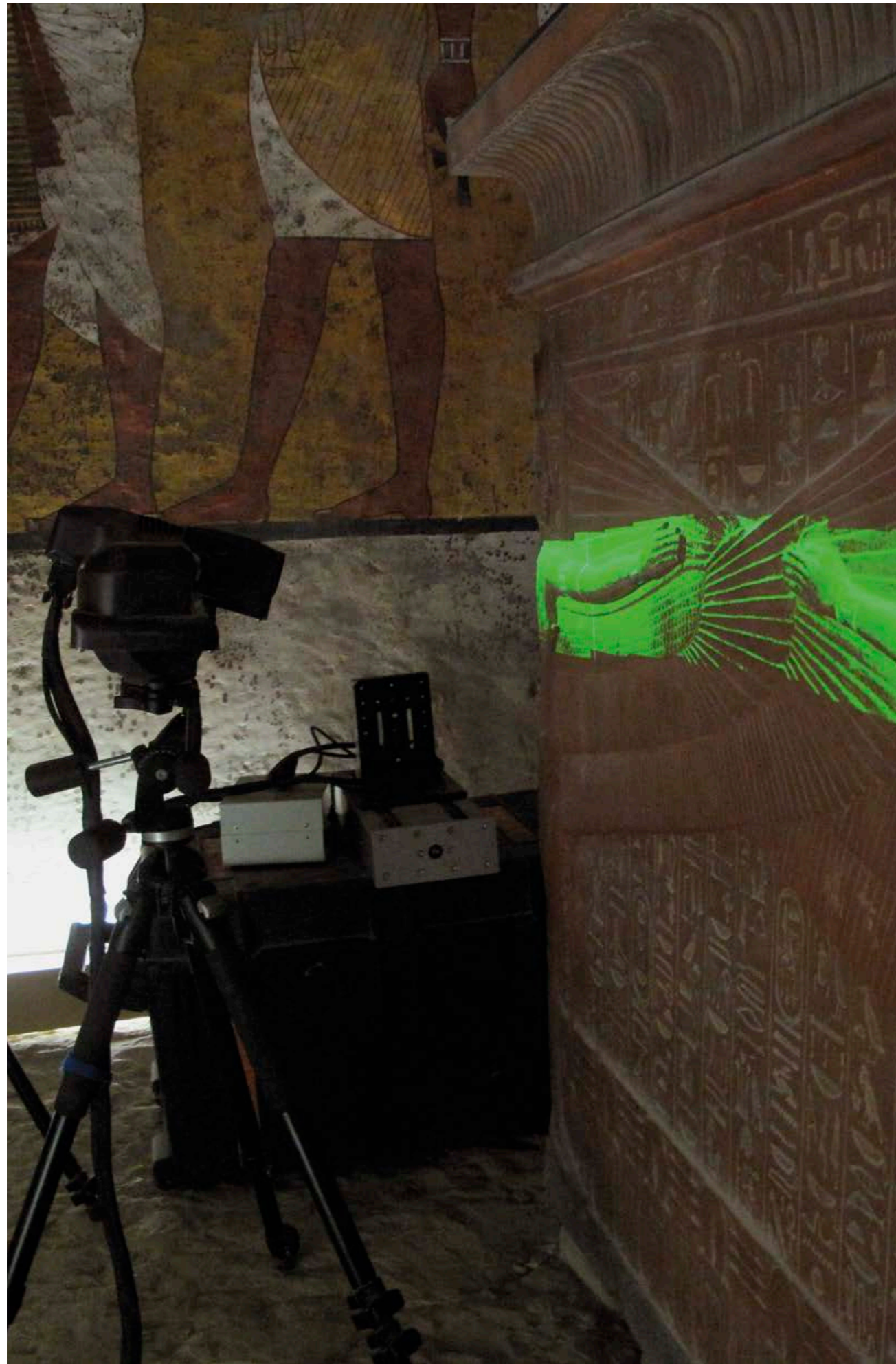
- RECORDED IN 2016
- RECORDED IN 2019

SETI I. RECORDING PROGRESS: LIDAR 3D SCANNING

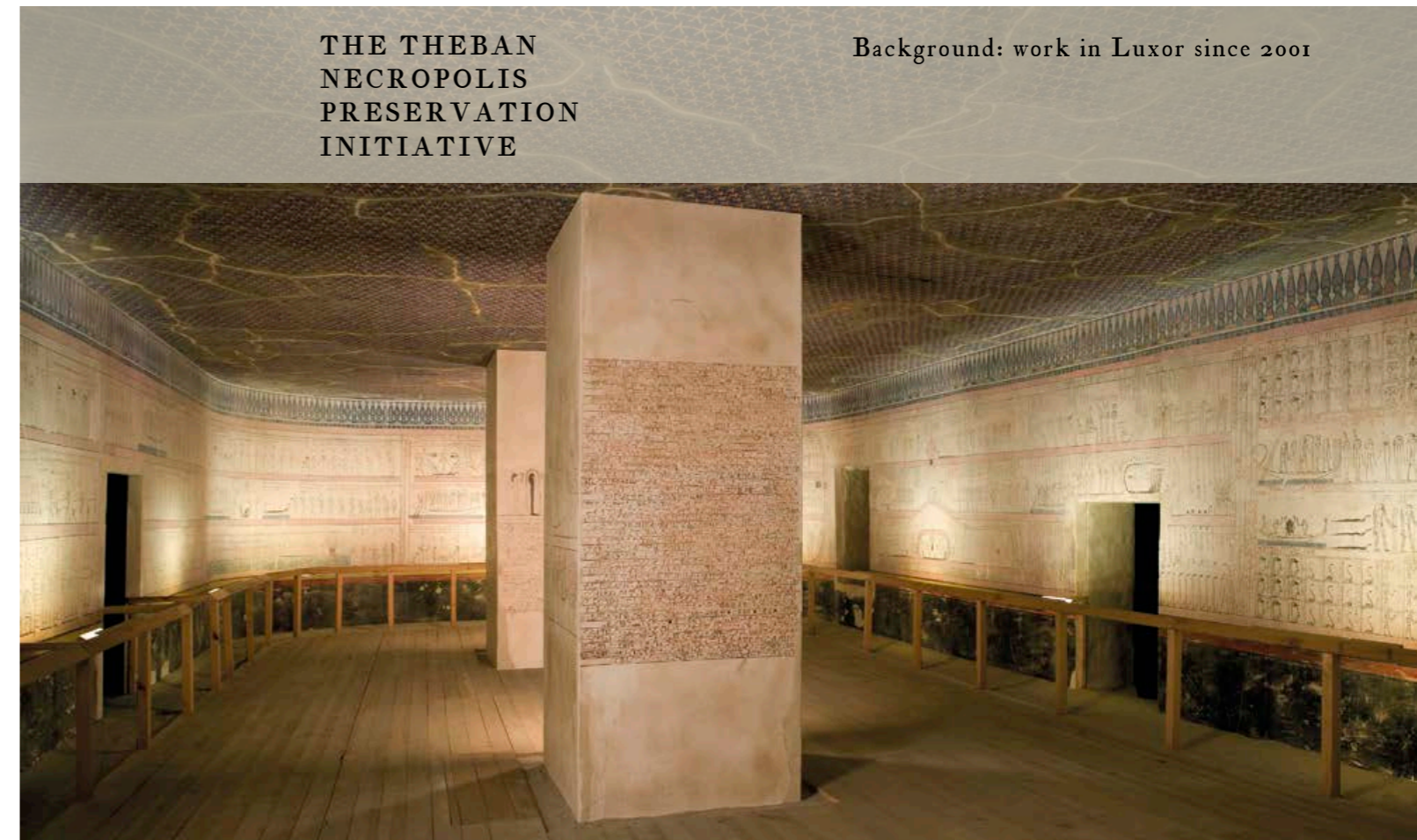


RECORDED IN 2016





Recording the sarcophagus of Tutankhamun with a Nub 3D structured light scanner, 2009.
 Previous page: Using a colour checker to record accurate colour in the Sarcophagus Room in the Tomb of Seti.



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Background: work in Luxor since 2001

Facsimile of the Tomb of Thutmose III, displayed in the the Antikenmuseum Basel, 2009. Photo by Andreas F. Voegelin.

In 2001, Factum Arte started work in the Valley of the Kings, conducting pilot recording projects in the tomb of Seti I with the intention of eventually creating a complete facsimile of the tomb. It was a time of great developments in digital recording and facsimile production: 2001 was the year in which the reconstruction of the cave of Altamira opened, and the copies of the Lascaux cave produced since 1983 had proved that facsimiles can become major visitor attractions if people understand the conservation issues involved in visiting originals. In 1988, the Society of Friends of the Royal Tombs of Egypt had suggested that a facsimile of the tomb of Seti I would be the best way of ensuring the tomb's survival and accessibility. For the 2001 recording project, 16 square metres of the tomb's surface were recorded at a resolution of 100 microns, which even today is rarely matched by digital recording specialists – the 3D recording in the tomb of Seti I is 2500 times higher than the recording from which the Altamira facsimile was made. Factum's policy is always to record at the highest resolution possible, in the most forensically accurate way that will ensure a close correspondence between the original and its actual-size replica.

The first Seti facsimile was followed in 2002 by a replica of the tomb of Thutmose III, the keystone of a touring exhibition, *The Quest for Immortality: Treasures of Ancient Egypt*, (National Gallery of Art, Washington 2002).

In 2009, the non-profit Factum Foundation was formed to take over Factum Arte's cultural heritage work, with the immediate aim of recording the tomb of Tutankhamun. The Theban Necropolis Preservation Initiative (TNPI) was also formed, as a collaboration with Erik Hornung at the University of Basel and with Theodor Abt from the Society of Friends of the Royal Tombs in Egypt. TNPI recorded the tomb and made public the data, allowing scholars and conservators to monitor its condition.

In 2012, a physical facsimile of the burial chamber of Tutankhamun was given to the people of Egypt. Since 2014, the facsimile has been installed in an underground building next to



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Background: work in Luxor since 2001

Carter's House at the entrance to the Valley of the Kings. The facsimile burial chamber is presented exactly as it is in the original tomb; the antechamber and annexe, while they retain the same proportions and materials as the original, are designed as an exhibition space. This permanent exhibition explains the degradation of the tomb since its discovery and the impact of mass tourism, and contains a recreation of the missing section of the South Wall of the burial chamber, which disappeared after the tomb's discovery in 1922.

In 2016, the TNPI embarked on the complete recording of the tomb of Seti I and the first local Egyptian operators were trained. In parallel with the scanning in Luxor, painted wall fragments and other objects removed from the tomb were recorded at museums and in private collections across the world. When it is finally finished, the facsimile will be even more complete than the original as it now stands, integrating within the reproduction many of the fragments removed from the tomb in the 19th century. The fragments will be shown in their current condition, focusing attention on the dynamic nature of originality: over the course of two centuries, different fragments have aged, and been restored, in very different ways. The facsimile will also incorporate all the painted fragments discovered in recent excavations by the University of Basel.

In October 2017 the first facsimiles were exhibited as part of the exhibition *Scanning Seti: The Regeneration of a Pharaonic Tomb* at the Antikenmuseum in Basel, marking the bicentenary of the discovery of the tomb. The full-scale exhibition included facsimiles of Rooms I and J, and a facsimile of Seti's sarcophagus, whose original is housed in Sir John Soane's Museum, London.

Also in 2017, the restoration of Hassan Fathy's Stoppelaëre House – a major work of Egyptian mid-20th-century vernacular modernism – was completed. This provided a base for the TNPI in Luxor, and a new 3D Scanning, Training and Archiving Centre was established there for the training of Egyptian digital cultural heritage specialists. The restoration was funded by Factum Foundation in exchange for use of the house for 10 years.

In February 2017, the Theban Necropolis Preservation Initiative team moved into Stoppelaëre House and recording work restarted in the Sarcophagus Room within the Tomb of Seti. A training program began at the Centre which by 2022 should have trained ten local people in a range of recording technologies, providing them with skills which can be transferred to other projects within the Valley of the Kings and beyond. The first four trainees, mainly employees of the Ministry of Antiquities selected by the Ministry in conjunction with Factum Foundation and the University of Basel, have already completed training.

In 2018, Factum's team continued to work in the tomb while the new centre was equipped with scanning, data processing and archiving equipment. While scanning is now underway, the work to bring the Centre's equipment fully up to date is still ongoing.

In 2019, the Initiative received the official patronage of the Egyptian National Commission for UNESCO. Since then, the TNPI has continued to record the tomb, including parts of it which have been removed from the structure itself.

Preservation used to mean removing parts that were considered significant to the great European collections. Now preservation is both local and global, redefining ownership and sharing, communication and value.

Opposite: Render comprising 3D and color data from Room K in the tomb of Seti. Marmoset Toolbag 3 was used for real time rendering, creating the effect of light and shade. The data was captured in 2001, but it only became possible to visualise it at this resolution recently.



Abdel Raheem Ghaba, Amany Hassan Mohamed and Mahmoud Salem scanning with two Lucida 3D Scanners in 2019.

The Theban Necropolis Preservation Initiative has three primary aims, all equally important:

The first aim is to create high-resolution digital records of tombs within the Valley of the Kings, with an initial focus on the tombs of Tutankhamun and Seti I. These recordings are accurate enough that the data can be rematerialised at a 1:1 scale, as facsimiles which, to the naked eye at a normal museum viewing distance, are indistinguishable from the originals. The TNPI recording campaigns result in uniquely complete archives of material: for the tomb of Seti I, the Initiative is scanning not only the tomb itself in its current, heavily compromised state, but also all known fragments and contents from Egypt and elsewhere, which will be incorporated where possible into future digital models and facsimiles. This effort to incorporate the fragments within the final datasets has been an aim of the project since 2001, when the first scan was conducted in the tomb of Seti.

The second aim is to transfer digital recording skills and technologies to members of the local community through an integrated training and educational program, building capacity and leaving them with the tools to initiate their own projects and conduct their own recordings in the future. Members of the local community who are working with Factum Foundation are extremely capable and often more ingenious and resourceful than graduates of the best western universities. It is vital to the TNPI that the local community benefits financially from the preservation of cultural heritage through the provision of new skills and employment to reinforce their sense of ownership.

The third aim is to make this digital documentation widely available. As the project develops, the data generated will be stored locally and made accessible globally via easy-to-use internet browsers – a process which is already underway. The copyright for all current and future commercial applications belongs to the Egyptian Ministry of Antiquities, but the recordings can be seen by anyone who is interested, allowing conservators, heritage professionals, academics, and the general public to examine these extraordinary remnants of our shared past in unprecedented detail. The recordings make it possible to monitor the condition of the tombs, providing objectively accurate evidence of changes to the surface caused by tourism and even by conservators' interventions intended to halt decay. They also permit the production of facsimiles, allowing audiences around the world intimate encounters with these extraordinary monuments of world heritage without risk to the fragile originals. Initial documentation and study of the fragments will be carried out by the University of Basel project in the Valley of the Kings, led by Dr Elina Paulin-Grothe and Susanne Bickel, but it is likely that the recordings will also lead to wider scholarly research on the tombs and even new discoveries – as has already been the case for the tomb of Tutankhamun (discussed later in this report). It is hoped that, using the ARCHiVe initiative, machine learning technology and AI can also be used to analyse the data.



Top to bottom:

A visit to Stoppelaëre House.

Aliaa Ismail (bottom left) teaching the use of the Lucida 3D Scanner to Amany Hassan and Mahmoud Abdallah, the first two trainees from the Ministry of Antiquities.

Aliaa Ismail, Amany Hassan and Mahmoud Abdallah.

Abd el-Raheem Ghaba and Mosa el-Sayed disassembling a Lucida Scanner for transport to the tomb of Seti.



The TNPI team. Left to right: Ashraf Gad (the Inspector from the Ministry of Antiquities), Mahmoud Abdallah, Abdo Ghada, Mahmoud Salem, Mina Fahim Razik, Amany Hassan, Aliaa Ismail, Hagar Ahmed. Mosa el-Sayed is missing from the photo.

The Theban Necropolis Preservation Initiative was set up to ensure that the local community benefits financially and in other material ways from international efforts to preserve cultural heritage in the Valley of the Kings, and also that Egypt's rich cultural heritage benefits from the knowledge and skills of local people. In order to achieve these aims, the TNPI has established a new 3D Scanning, Training, and Archiving Centre in Hassan Fathy's Stoppelaëre House at the entrance to the site, where a training course in recording and digital processing methods provides new skills and employment to local people.

The Centre is run by Aliaa Ismail, an Egyptologist educated at the American University in Cairo and at UCL in London. Between 2019 and 2022 ten trainees, on secondment from the Ministry of Antiquities and chosen from a shortlist of candidates proposed by the Ministry, will pass through the training program. The trainees enter the program in cohorts of two, with each pair of newly trained operators subsequently helping to train those who follow them. Over the course of the six-month program, trainees learn skills including laser scanning, photogrammetry, colour recording, data processing, archiving and data dissemination. Between 2019 and 2022, the Centre will focus its scanning efforts on recording the many fragments (more than 8,000) from the Tomb of Seti which are held in the Valley of the Kings, many of which were uncovered in recent excavations in the nearby Tomb of Ramesses X. The data from this project will be stored in a digital archive in Stoppelaëre House and, as well as by Basel University who are studying the fragments.

Factum Foundation specialists will provide additional training at the Centre, as well as offsite support, but the aim is for the team to be able to operate with as little external input as possible. As more trainees graduate, more of the data processing will take place in Luxor rather than in Madrid, and the ultimate goal is a self-sustaining centre which offers long-term digital recording and archiving facilities while bringing new skills to the West Bank.

Once the fragments from the Tomb of Seti have been recorded, it is anticipated that the team will be able to take on new digitisation projects in the Valley of the Kings and beyond, working both for the Ministry of Antiquities and for the many foreign excavation teams operating in Egypt.



ALIAA ISMAIL

Aliaa Ismail first met Adam Lowe, the Founder of Factum Foundation, at the opening of the facsimile of Tutankhamun in 2014. Having completed a BA in Architecture, Engineering, and Egyptology from the American University in Cairo and being greatly interested in the interdisciplinary merging of technology with heritage documentation and preservation, she was fascinated by the Foundation's work. She has worked with Factum Foundation since 2014, serving since 2016 as Director of the TNPI in Luxor. Aliaa oversees the scanning operations within the Tomb of Seti I, organizes and teaches the training program at the Centre for Scanning, Training and Archiving (at Stoppelaëre House), liaises between the TNPI and the Ministry of Tourism and Antiquities, and presents on the Initiative's work within the English- and Arabic-speaking media. She recently gave a TEDx talk on her work for the TNPI. In 2019 she completed an MRes at the UCL Institute of Sustainable Heritage.



ABDO GHABA (ABD EL-RAHEEM GHABA)

Abd el-Raheem Ghaba, known as Abdo Ghaba, is a resident of the local community in Gournah, living in the Hassan Fathy village. He has had a diverse career which has included organizing tourist tours, driving, wiring electricity and managing the farming of his own land. Abdo met Adam Lowe in 2009 when he started working with the team on the Tutankhamun recording and facsimile project; at the time Abdo was performing jobs such as driving the team to site and back. In 2014, Abdo was a great help in the construction of the physical facsimile that currently stands at Carter House. He moved all the facsimile fragments from the storage to the site location, a complex task due to their size and weight. Unfortunately, however, tragedy hit and Abdo was bitten by a horned viper, leading to the loss of his kidneys; he also lost his brother in the same year. However, Abdo's resilient nature did not allow him to give up. In 2016 he started his training with Aliaa Ismail, learning to operate the Lucida scanning system, and has since become expert in scanning as well as data processing. Today, Abdo plays an important role as assistant manager of the TNPI, helping to lead the training program and sharing his knowledge with other members of the team.



AMANY HASSAN

Amany Hassan is an inspector working at the ministry of Tourism and Antiquities. She lives in Gournah Village with her family. Her journey with TNPI started in 2016 when she was first assigned to the project as an accompanying inspector. Amany was like no other inspector that has been assigned to the project, and was very interested in the work that was carried out, asking questions, taking notes, and helping out in various tasks. Seeing her motivation, it became clear that she would play an important role in the future of TNPI, particularly when the Minister of Antiquities made it clear that he would like TNPI to train members of the Ministry to help bridge the space between the old ways and new technologies for heritage preservation. In early 2019 Amany was the first to be chosen to undertake such training after meeting with a panel of interviewers from Factum Foundation, the University of Basel and the Ministry of Antiquities. After 6 months of training, Amany passed the exams with distinction and joined the team as a professional 3D scanning technician. Today she is scanning, data processing and capable of managing a 3D scanner on her own.



MOSA EL-SAYED

Mosa el-Sayed already had a long history with the project to scan the tombs even before the TNPI came into existence. Mosa met Adam Lowe in 2001, when the first scanning trial took place in the burial chamber of the tomb of Seti I. Mosa was then a young boy ferrying tourists between the East and West Banks of the Nile aboard his motor boat. A friendship started then and there. On every trip made by Adam or other members of Factum, Mosa heard about the projects done for protecting heritage and started gaining interest. Mosa's interest in antiquities grew and he became a guardian at the Valley of Kings. In 2016 when TNPI was established, he joined the team. Mosa was intrigued by the mechanics of the different parts of the scanning system used and started learning about the assembly of the scanning system. However, Mosa's lack of literacy in the English language and computers prevented him from progressing further than the mechanical process. Nonetheless, 2020 was a great year of determination for Mosa, and against all the odds he decided to further his knowledge in 3D scanning and play a role in TNPI. Under the instruction of Aliaa Ismail, Mosa commenced his training mid-July 2020 and has shown great willpower in learning. It is expected that by early 2021 Mosa will have completed his training and will be an official member of the TNPI 3D scanning Team.



Abd el-Raheem Ghaba processing data at Stoppelaëre House.



Scanning with the Lucida in Room J.

The training program established by the Centre for 3D Scanning, Training, and Archiving lasts 6 months. All trainees must come from the local area, preferably from the West Bank, and all are on secondment from roles in the Ministry of Tourism and Antiquities. They are selected following an interview and an assessment test regarding views on heritage protection and cultural preservation. After the completion of the initial program, trainees spend a further 6 months cementing their skills by teaching them to the next cohort. Aliaa Ismail, the lead instructor, oversees this process throughout. The training modules are as follows:

First Training Module: Scanning with Lucida 3D Scanner

In the first training module, the trainees are introduced to digital heritage preservation and to the different methods employed. They learn about Lucida 3D Scanner set-up (assembly of the main structure), calibration process, scanning process, and troubleshooting.

Second Training Module: Processing Applications I

In the second training module, the trainees start learning about the different processing applications for the 3D data scanned by the Lucida 3D Scanner. Over the course of this module, they cover the different steps of processing and the apps that have been designed specifically for the data generated by the Lucida 3D Scanner: the Merging App, the Editing App and the Bending App.

Third Training Module: Processing Applications II

In the third training module, the trainees continue learning about the different processing applications with focus on a different set of software, PTGui and Global Mapper.

Fourth Training Module: Photogrammetry

In the fourth training module, the trainees begin to learn about photogrammetric recording techniques and data processing. They learn about obtaining a 3D model from a set of photographs and using a DSLR to capture these photographs.

Fifth & Sixth Training Modules: Internship I & Internship II

The fifth and sixth training modules are an internship where the trainees are expected to carry out the different processes that they learned, demonstrating that they understand the nature of the work and can implement it.



Scanning in the Sarcophagus Room with two Lucida 3D Scanners.

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Scanning completed in the Tomb of Seti,
September 2019 - September 2020



The team entering the Tomb of Seti I on a normal day before the Covid pandemic.

In the past year, the TNPI team has achieved the following:

- Training 2 new trainees, Hager Ahmed and Mina Fahim Razik, from the Ministry of Tourism and Antiquities
- New recording of colour data for the tomb of Tutankhamun, allowing a comparison between the condition of the tomb 10 years ago with its condition today
- Obtaining all needed permissions and security clearance for 2020
- Managing to reach and scan challenging areas in the tomb of Seti I
- Training the team to assemble, disassemble and use the scaffolding
- Scanning in the Sarcophagus Room (Room K), Room Jb, Room Je, Corridor G, and Area H
- Maintaining all equipment and storing all structures in the tomb properly before cultural heritage sites were closed due to COVID-19 shutdown
- Returning to the tomb as soon as restrictions were lifted, making the TNPI team the first team to return to the Valley of the Kings
- Editing all scanned files
- Establishing and maintaining strong relations between TNPI and the Ministry of Antiquities
- Conducting preliminary recordings in the campaign to record the 8,000 fragments onsite in the Valley of the Kings
- Repairing equipment at Stoppelaëre House
- Engaging in discussions with the Grand Egyptian Museum which are likely to lead to the installation of a new facsimile of the tomb chamber of Tutankhamun within the museum complex, and may also lead to an exhibition focused on the tomb of Seti I within the museum.



Recording fragments in the tomb of Ramesses X (KV 18).

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Recording the fragments of the Tomb of Seti I



The fragments as they were before the work of the University of Basel, 2001. Room Jd.

One of the distinguishing features of the project to record the tomb of Seti I is that the recording will incorporate all known fragments of the tomb – meaning the eventual digital models and even physical facsimiles will be more complete than the original tomb itself. These objects contain vital evidence about the surface of the tomb and also help to understand the damage that can be found in the tomb. The project to record the fragments is one of the main focuses of the TNPI's work for the coming year.

The project is divided into two main parts: firstly, the recording of the thousands of fragments still within the Valley of the Kings, and secondly the recording of those fragments which are no longer in the Valley.

In the years following the discovery of the tomb in 1817, sections of the decoration were removed and there are now many fragments of varying sizes in museums and collections around the world. The largest are in the Musée du Louvre in Paris and the Archaeological Museum in Florence. Since 2016 fragments have been recorded by Factum Foundation at the Museum of Fine Arts, Boston, the Louvre in, the British Museum and Sir John Soane's Museum in London, the Archaeological Museums in Florence and Bologna, and in a private collection. Factum Foundation and the TNPI are committed to recording all of these fragments, as well as any existing squeezes – wax squeezes are thought to exist at the Museum of Fine Arts, Boston and the British Museum. Embossed paper impressions exist at the Griffiths Institute in Oxford.



Fragments from the Tomb of Seti I, stored in the entrance to the tomb of Ramesses X.



A fragment now in the Museum of Fine Arts, Boston.



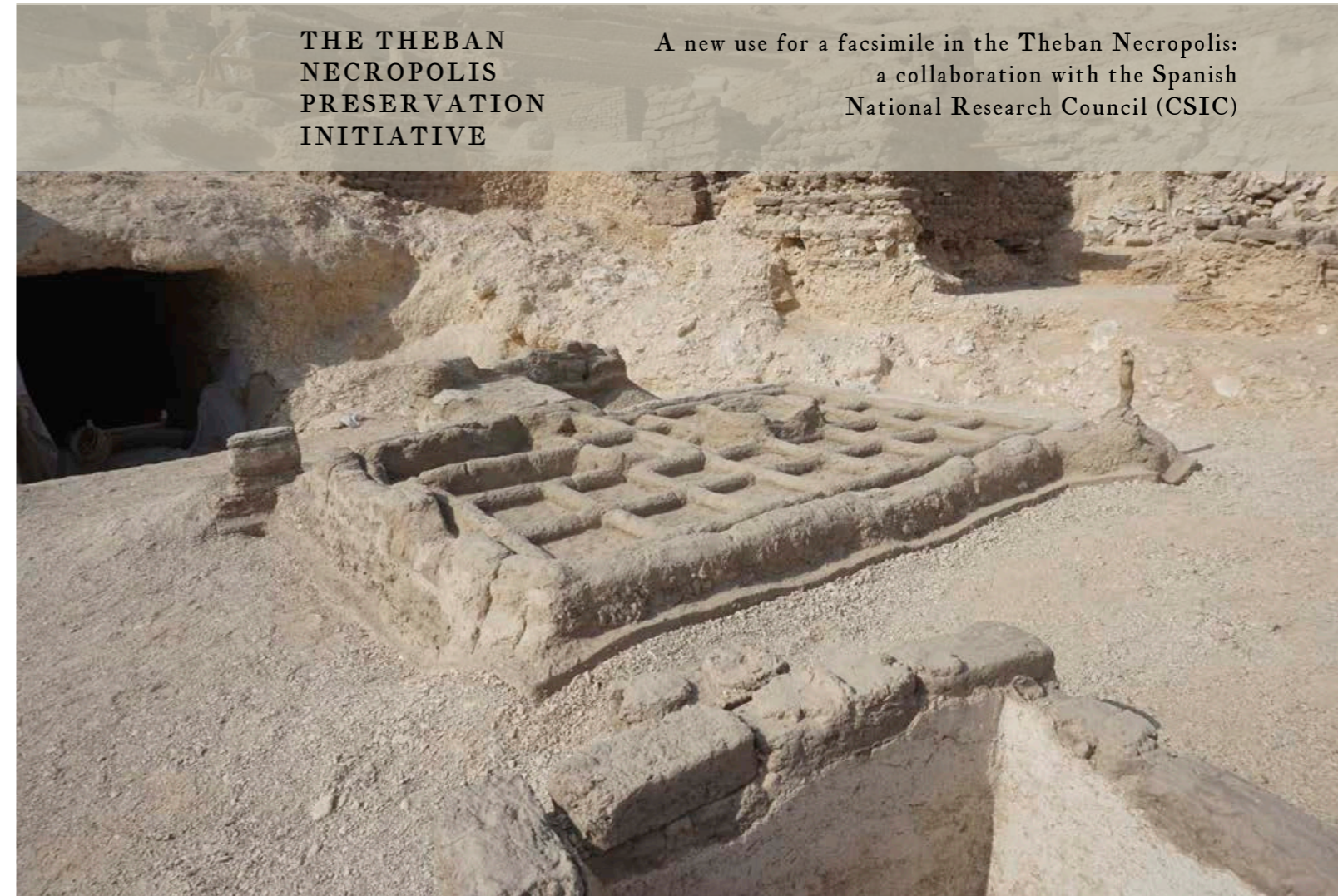
A large fragment of polychrome painting and relief carving in Room Jd, 2001.

There are also a large number of fragments of different sizes, some painted, some not, that were found in, or near, the tomb. The excavations carried out by Susanne Bickel and Florence Mauric Barberio near the adjacent tomb of Ramesses X (KV 18) between 1998 and 2005 brought to light roughly 8,000 decorated fragments from the Tomb of Seti I. Larger fragments were also found inside Seti's tomb where they had been stored for more than a hundred years.

The project to record the fragments is a highly ambitious one, and new equipment will be needed at Stoppelaëre House to ensure that recordings can be made in the tomb to the highest standard. In addition, as recording progresses, we are faced with the task of constructing an archive to store and organise the recorded fragments, and through which to make them accessible to the scholarly and cultural heritage community. Factum will also assist with the computer visualisations that will help with the study and re-integration of the fragments. In recent years, Florence Mauric Barberio and the team from Basel University have pieced together many fragments, but advances in recording hardware and analytic software will make possible far more effective manipulation of the thousands of fragments from the tomb, making a major contribution to the fledgling field of digital restoration, a fast-growing area of digital humanities.



Exact facsimile of the funerary herb garden discovered by José Galán (Proyecto Djehuty, CSIC). The original is very vulnerable and has been reburied. The facsimile was placed on top of the original site. This approach means it is both preserved and visible. Photos by José Galán.



**THE THEBAN
NECROPOLIS
PRESERVATION
INITIATIVE**

A new use for a facsimile in the Theban Necropolis:
a collaboration with the Spanish
National Research Council (CSIC)

Recent collaborations with the Spanish National Research Council (CSIC) have resulted in two recreations for study and display purposes, both relating to CSIC's excavations at the tomb of Djehuty in the Valley of the Kings.

In 2018, Factum used a LiDAR recording produced by CSIC to create a copy of a large stele from outside the tomb, which was exhibited outside the Templo de Debod in Madrid as part of an Egyptian writing workshop.

Between 2018 and 2020, a more ambitious project was undertaken, in which Factum rematerialised the funerary garden of Djehuty, which had been excavated in 2017 by CSIC. This Twelfth Dynasty funerary garden is the second Egyptian funerary garden ever to be excavated, and the first to receive proper archaeological documentation. It is in a remarkable state of preservation, complete with 4000-year-old traces of pollen and seeds from lettuces, shrubs, and trees. But as a structure made up of mudbrick the garden is extremely fragile, and the act of excavating it already will already have resulted in irreparable changes to its constitution and stability. In order to keep it from further erosion, the decision was made to cover the original garden with a protective structure and to create a model of it to display in the same spot, so that visitors to the tomb can see what the garden looks like without the garden itself undergoing further deterioration. The recreated garden was installed outside the tomb of Djehuty in January 2020.



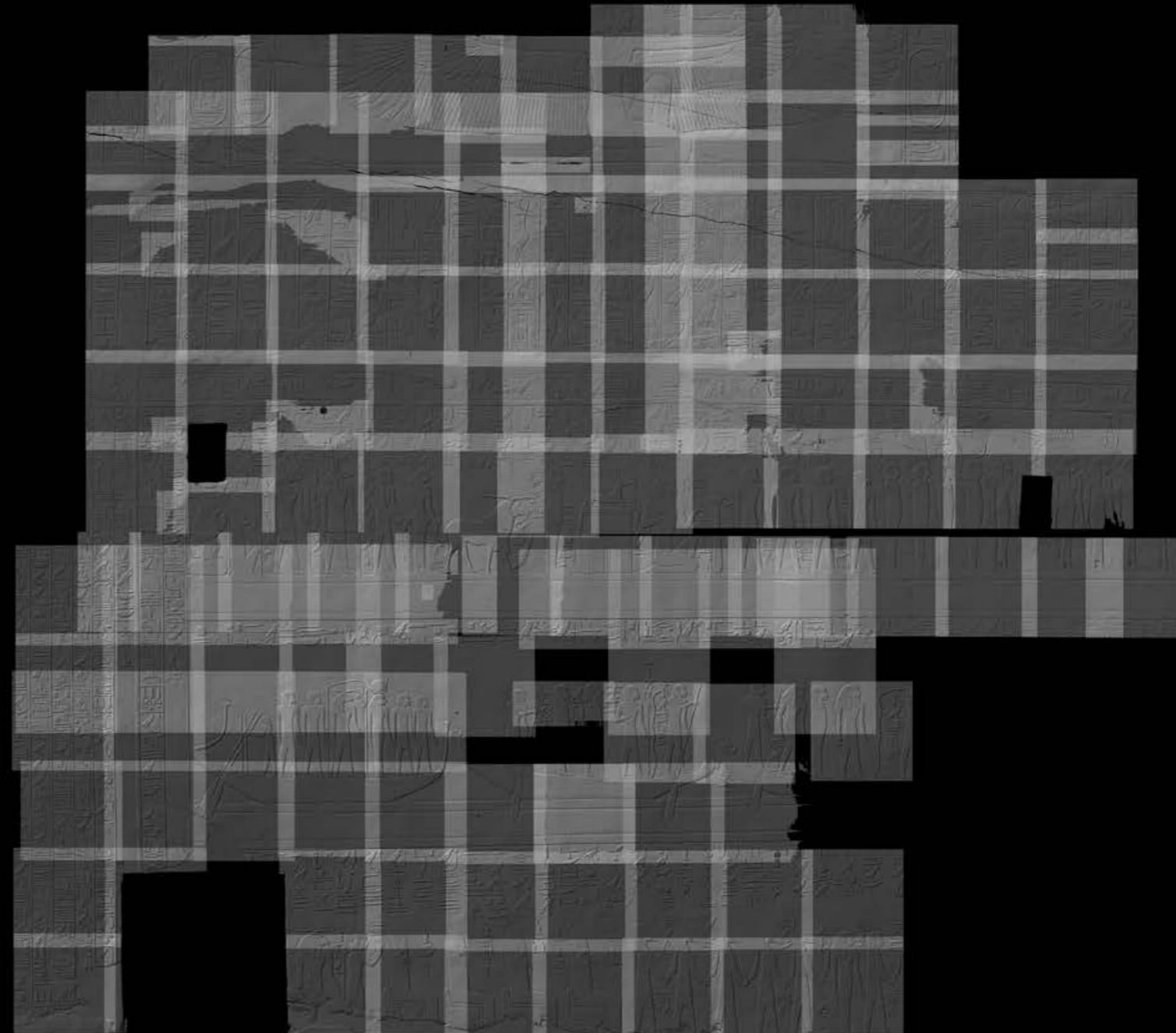
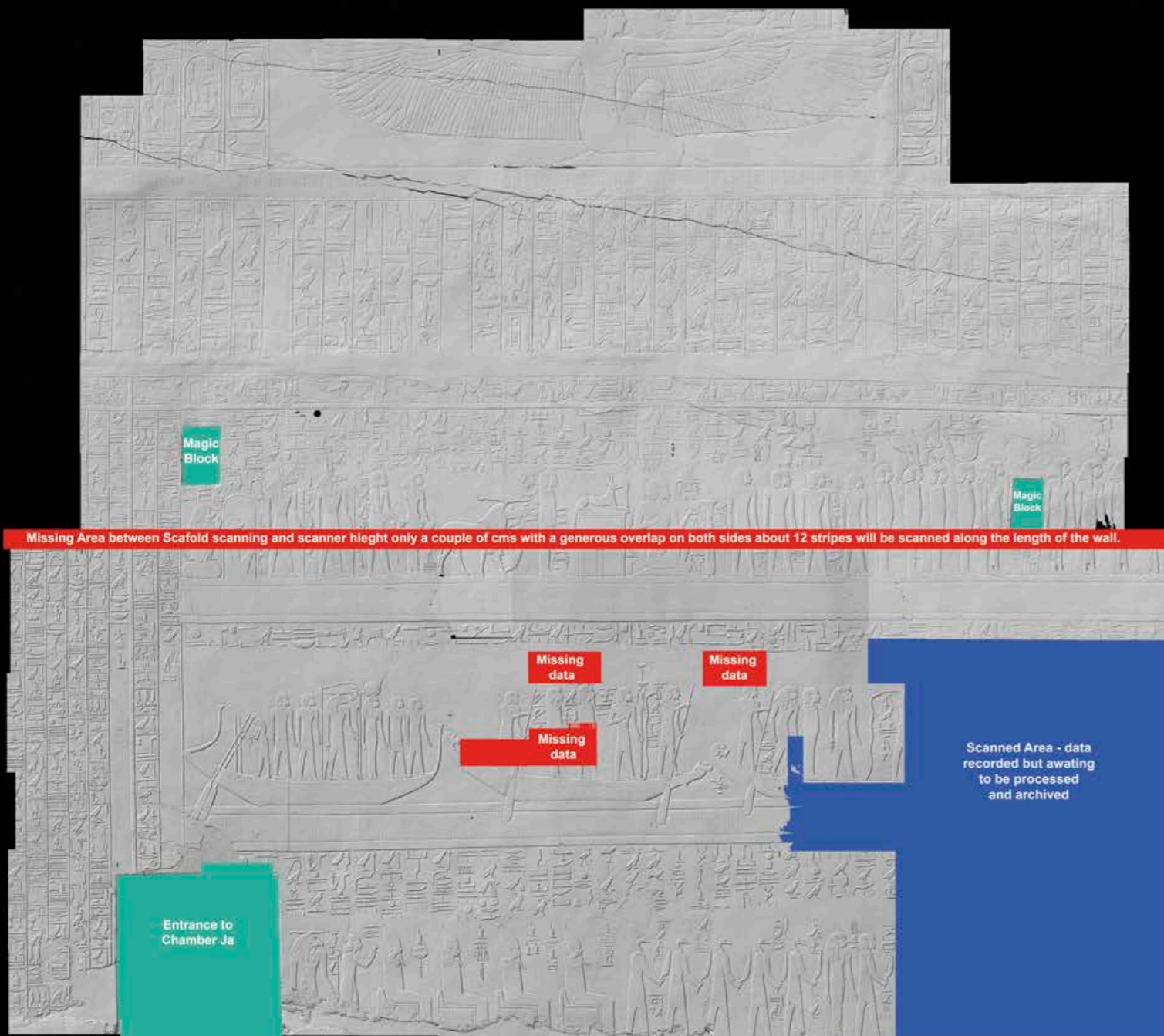
The TNPI's main achievements in 2019-20 include:

- the continuation of scanning in the tomb of Seti using the Lucida 3D scanner, LiDAR, photogrammetry, and composite photography;
- the training of two new employees on secondment from the Ministry of Tourism and Antiquities as digital heritage specialists (a second cohort had to be postponed due to the disruptions caused by COVID-19);
- the re-recording of the burial chamber of Tutankhamun;
- the initiation of the project to scan and archive the more than 8,000 known fragments from the walls and ceilings of the tomb of Seti;
- the installation of the replica of the funerary garden from the tomb of Djehuty;
- the online publication of the first version of the Virtual Reality 3D online application of the tomb of Seti I.

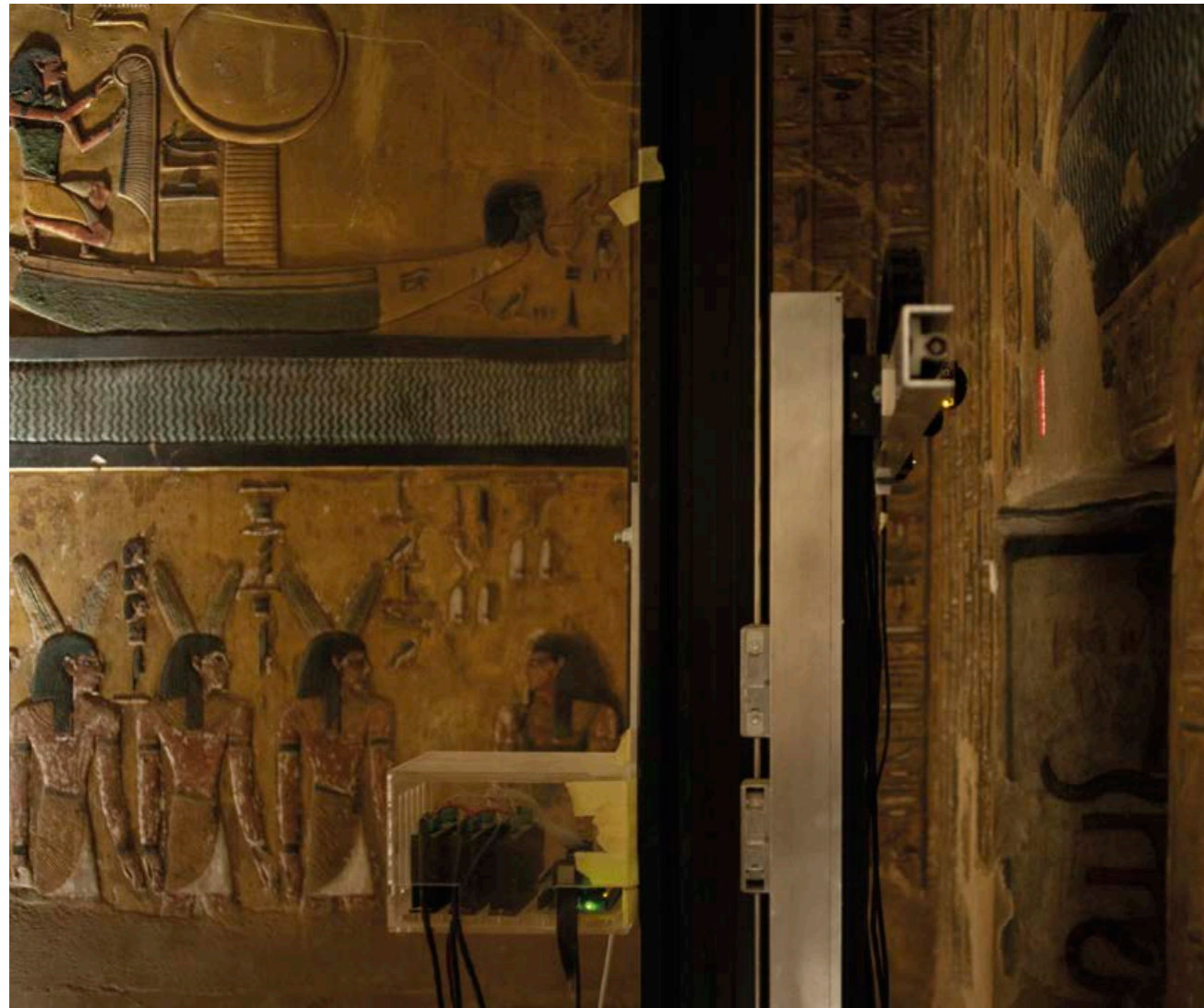
More detail can be found in the chapter on 'Ongoing Work'.

The TNPI's goals for the next 24 months are:

- the completion of scanning within the tomb of Seti;
- the recording and archiving of the more than 8,000 known fragments from the tomb's walls and ceilings;
- the training of seven more employees on secondment from the Ministry of Tourism and Antiquities in the techniques of digital scanning;
- the continued recording and archiving of those fragments not currently in Luxor, but located in museums and private collections elsewhere;
- the development of the digital archive for recording the fragments;
- the completion of the restoration of Stoppelaëre House, and the purchase and upgrading of much-needed computers, cameras, and other equipment for the Centre for Scanning, Training, and Archiving;
- possible collaborations with the Grand Egyptian Museum on the installation of a facsimile of the tomb chamber of Tutankhamun and an exhibition focused on the tomb of Seti I.



Tomb of Seti, Room K, west wall, an area of 20,7 sqm. Left: the colourless 3D relief data for the wall. Missing areas correspond to niches and protrusions which cannot be recorded with the Lucida, or to missing overlaps still to be recorded. Right: the diagram shows the different tiles (100 in total) recorded using the Lucida scanner; lighter areas show where there is overlap between tiles.



Scanning with the Lucida 3D Scanner.



Composite colour photography recording in Room J.



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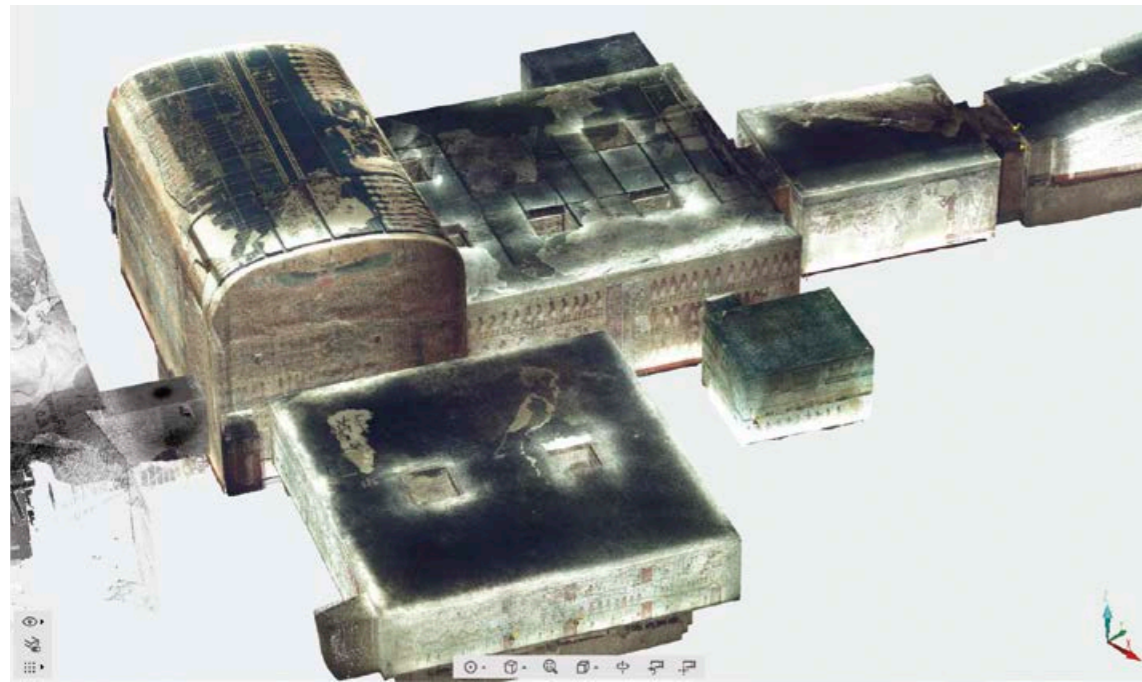
Repairing a Lucida in Stoppelaëre House.

Terms like high-resolution documentation and giga-pixel resolution are often used without a clear understanding of what is meant by this terminology in practice. In 3D scanning, high resolution can mean long-range area-scanning at a resolution of 100 measured points per square meter or can be used to describe close-range surface scanning with 100 million measured points per square meter. In colour recording, confusion still exists between images that appear to be high resolution on screen and images that still appear to be high resolution when printed at full size. For Factum Foundation and the TNPI, “high resolution” refers to scans of a quality sufficient that the data can be rematerialised as a 1:1 facsimile of the original, which to the naked eye at ordinary museum-viewing distance (and usually much closer) is indistinguishable from the original.

In order to create these recordings, Factum uses commercially available scanning equipment, custom-made scanning equipment developed in-house, and commercially available equipment adapted to suit the specific needs of cultural heritage recording.

All the data recorded in the Tomb of Seti I is stored and archived in its raw format. It requires processing in different ways for use in different applications. Screen viewing requires one approach, the production of a facsimile another. All the raw video data is currently stored on external hard drives. Data is backed up in Madrid, and an archival storage system will be installed in Stoppelaëre House before the end of 2021. Storing digital data in different forms and in different places is critical to its long term survival.

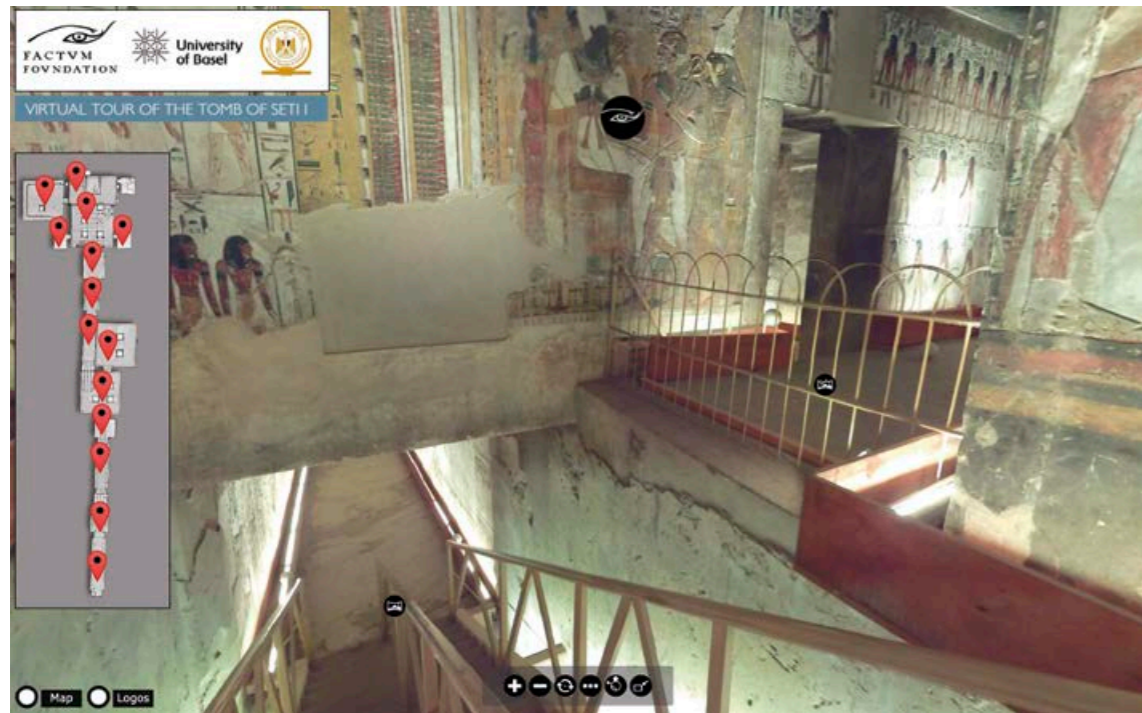
The data processing is done in Stoppelaëre House and in Madrid. As more members of the local community are trained, more processing will happen on the West Bank with remote access management support from Madrid. Combining different types of data is a complex part of the process, and is constantly evolving. LiDAR recording, the Lucida 3D Scanner, photogrammetry and composite colour photography are all required to ensure an accurate facsimile. The aim is to use computer vision technology and Artificial Intelligence to analyse and evaluate the recorded data, working with Analysis and Recording of Cultural Heritage in Venice (ARCHiVe) a partnership between Factum Foundation, the Cini Foundation and École Polytechnique Fédérale de Lausanne.



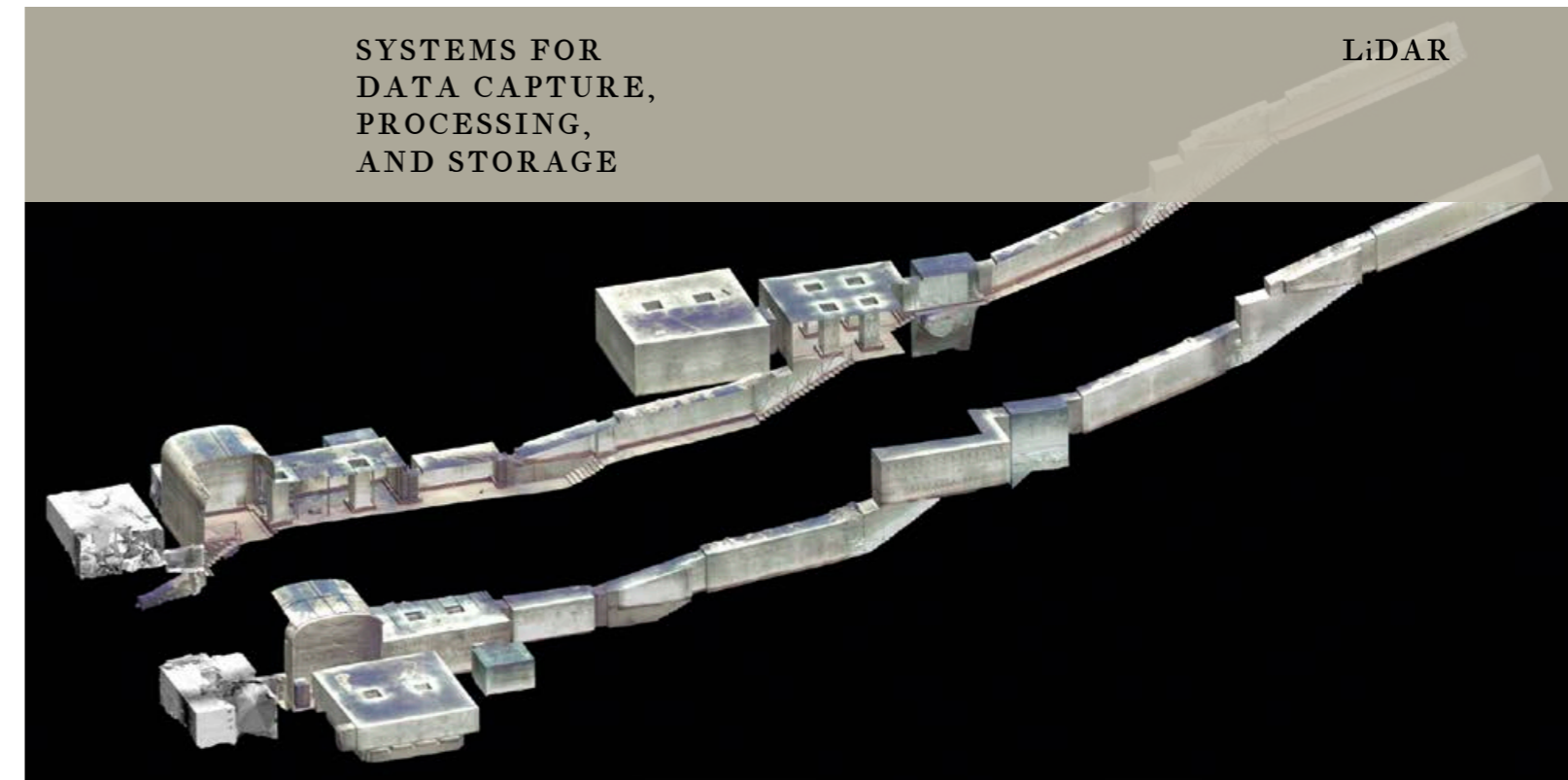
LiDAR data was used to create a complete model of the interior volumes of the tomb of Seti.



LiDAR data being processed in order to produce a walk-through model of the tomb.



LiDAR data used as the basis for the VR model of the tomb of Seti.



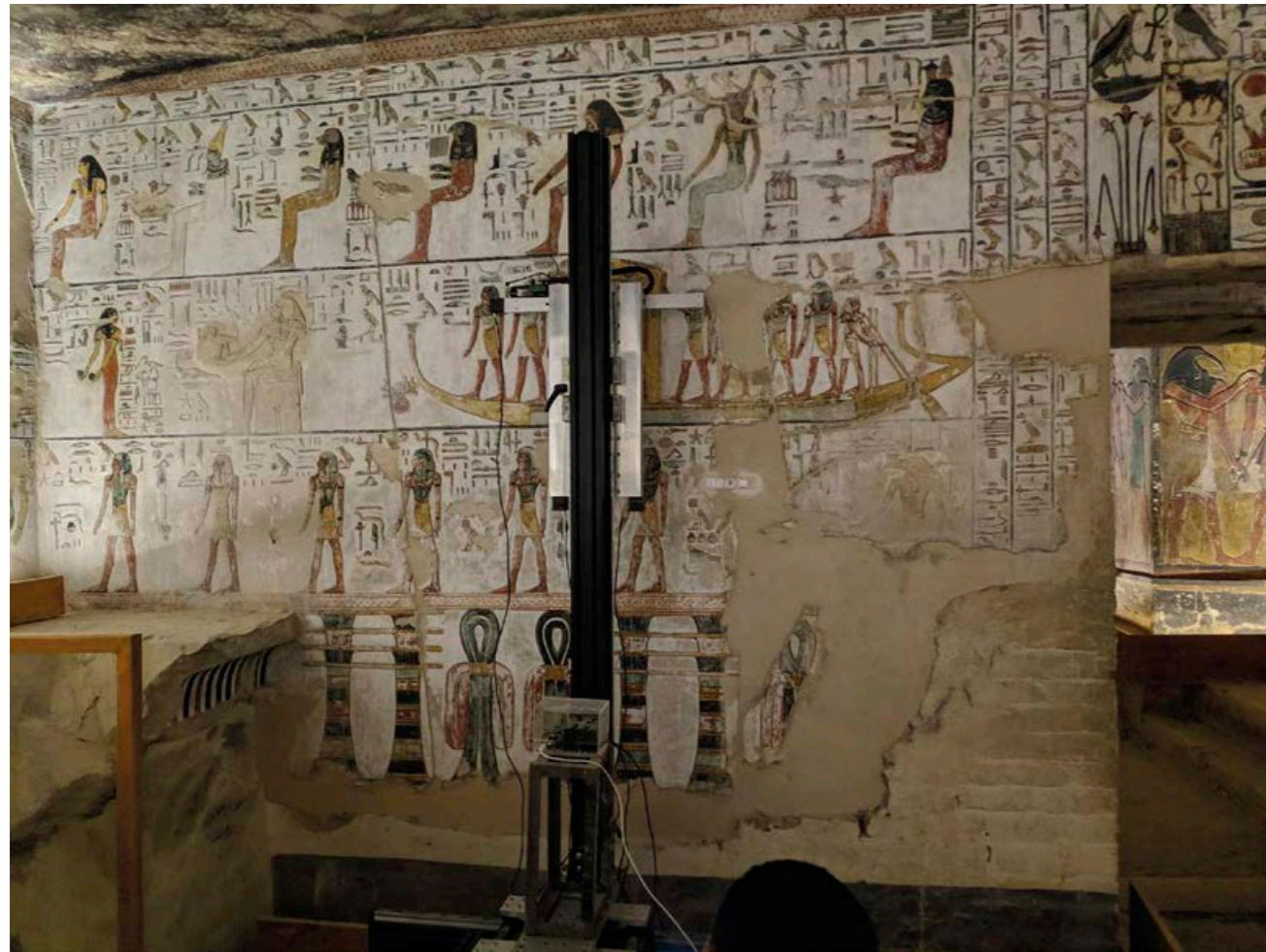
Split LiDAR model of the Tomb of Seti I for the *Scanning Seti* physical walk-through 3D model.



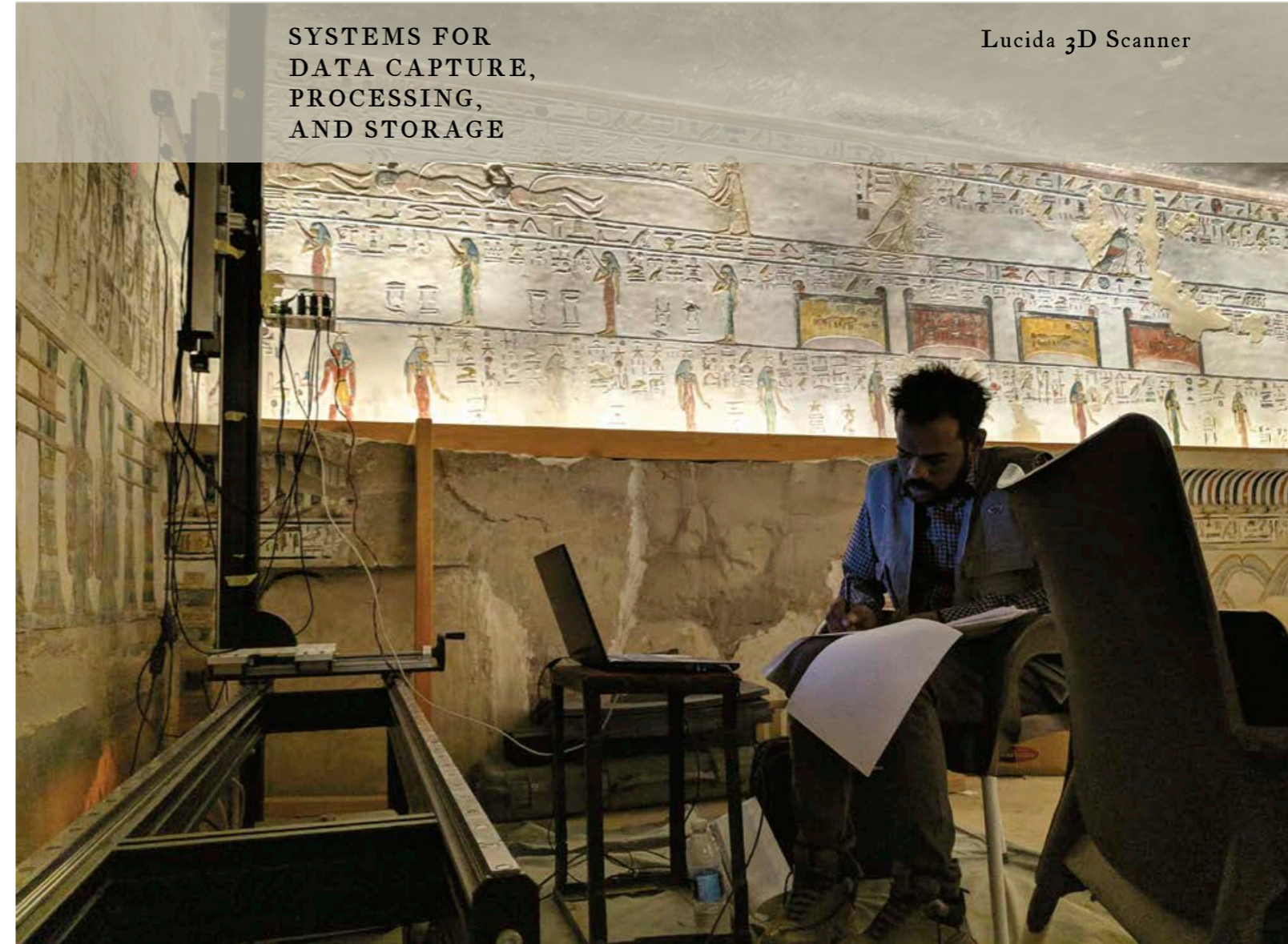
LiDAR scanner at the entrance to the tomb of Seti.

LiDAR is used in cultural heritage documentation to produce metrologically accurate 3D recordings of large spaces or objects. However, the data does not provide detailed information about the texture of a surface. Instead, it acts as a digital 'canvas' onto which higher-resolution 3D surface scans can be placed. For the tomb of Seti, a LiDAR scan was used to create a complete model of the tomb interior. This scan has many uses, from facsimile production to the metrological checking of other recorded datasets to the creation of the VR model of the tomb.

In 2016, the entire tomb of Seti I was recorded from 70 different scanning positions using a FARO Focus 3D x 130 HDR. However, LiDAR technology has now advanced and the new Leica LiDAR scanner represents a significant advance in this technology. In 2021 Factum will rescan the whole tomb using the Leica system.



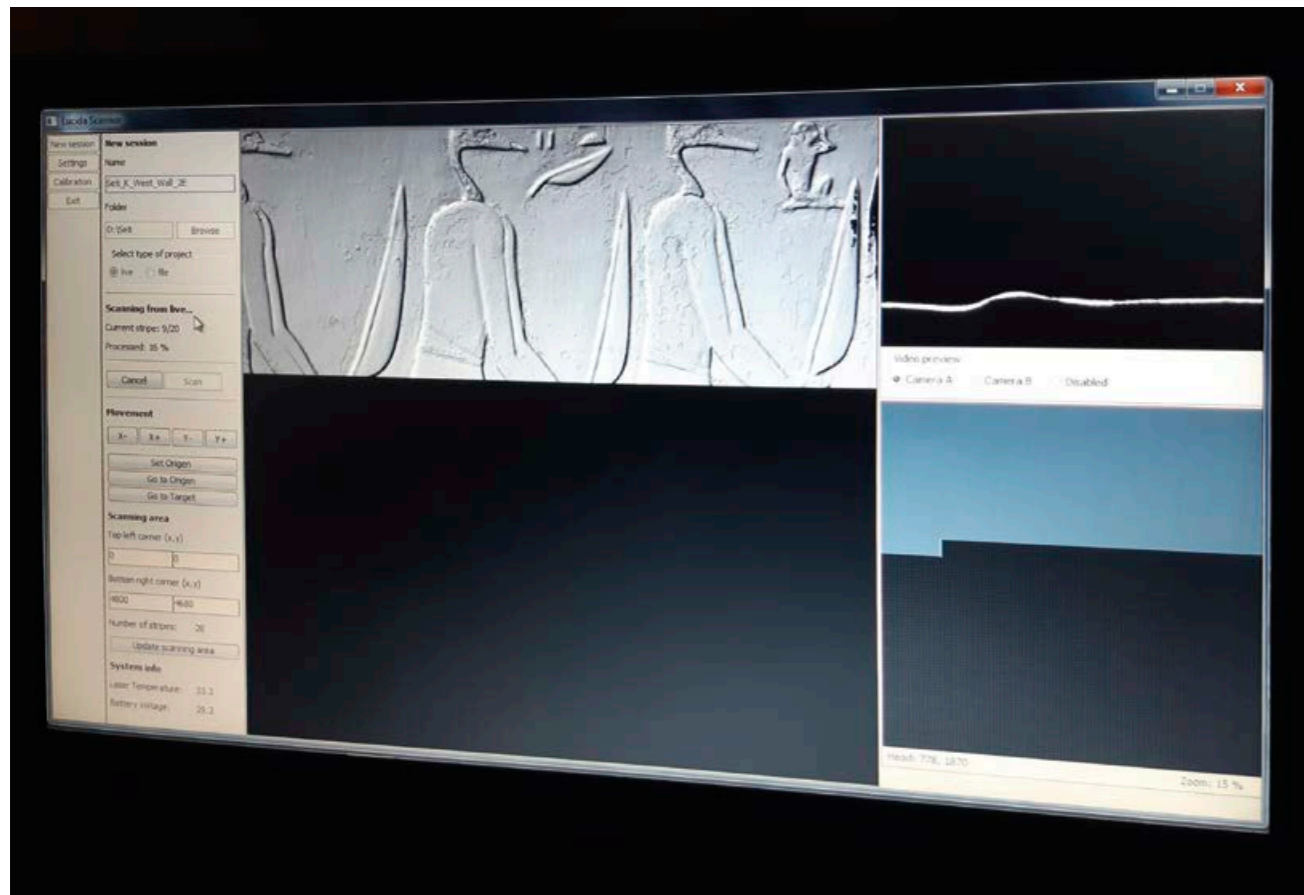
Lucida scanner in the tomb of Seti I.



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Lucida 3D Scanner

Abd el-Raheem Ghaba recording in the Tomb of Seti I using the Lucida Scanner. Keeping detailed and accurate records is a vital part of the documentation work.



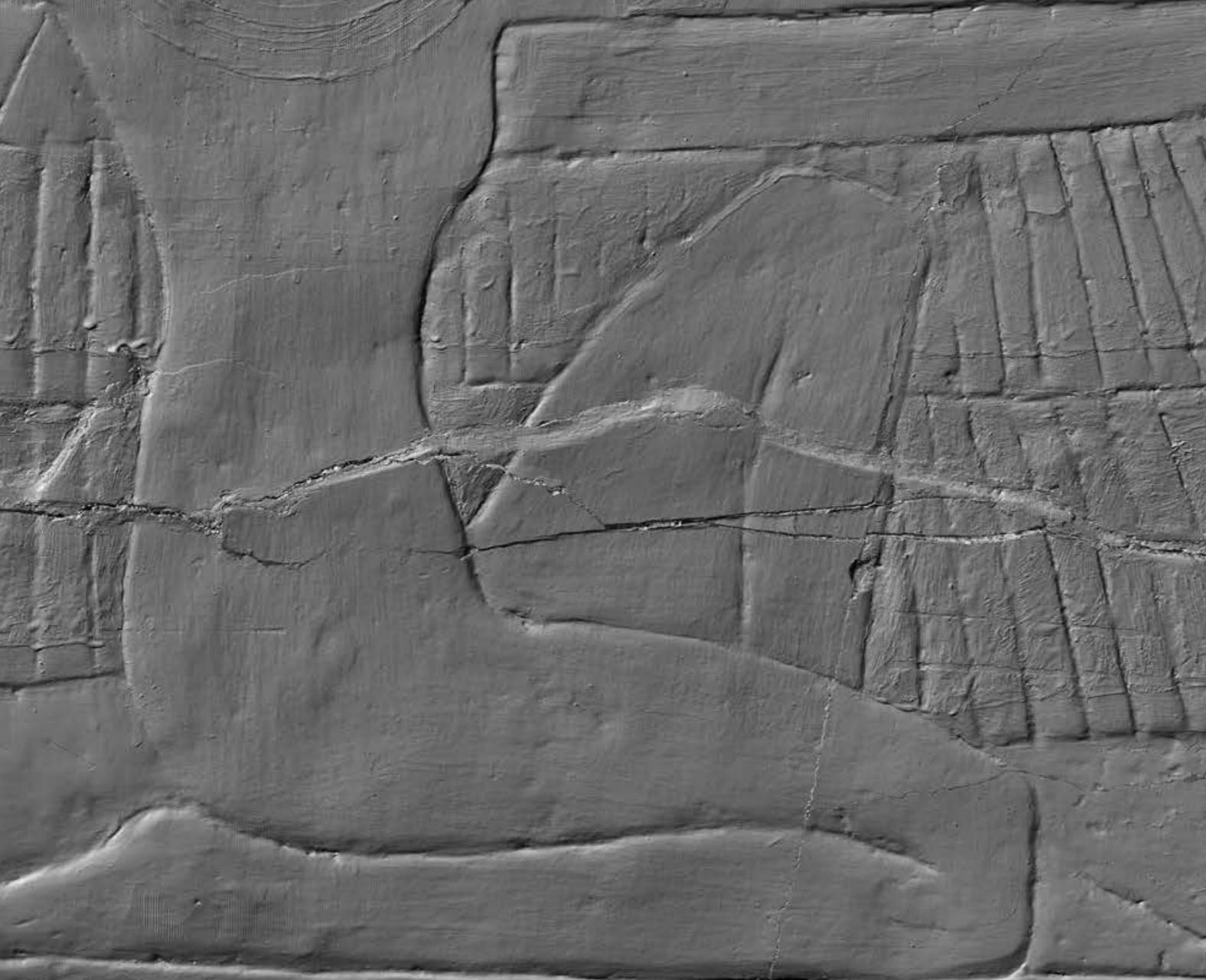
The Lucida app, partway through scanning a tile.

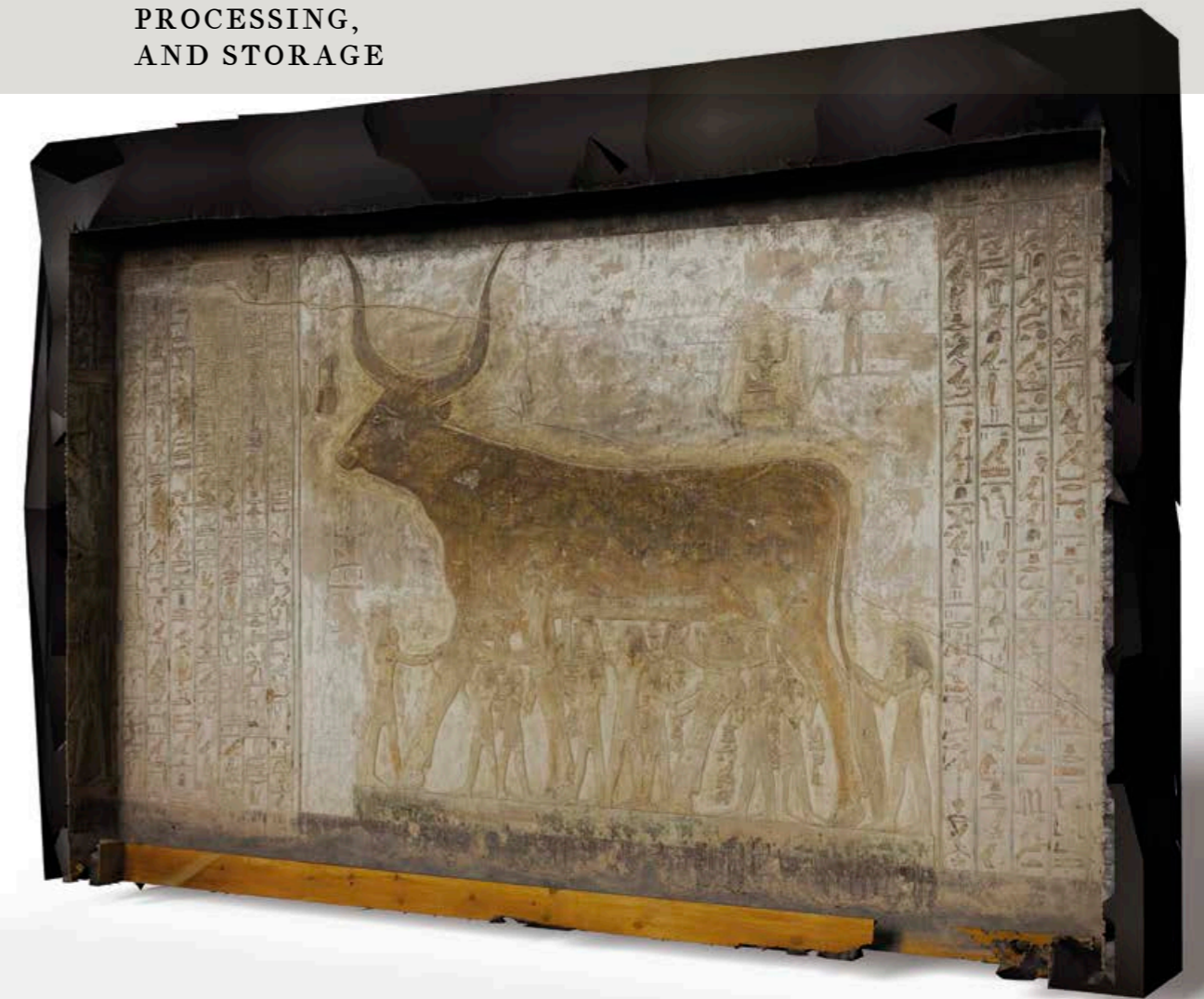
The Lucida 3D Scanner is the main scanning system employed for the high-resolution recording of surfaces within the tomb. It is a close-range, non-contact laser recording system that captures high-resolution surface texture data for low-relief surfaces such as paintings or bas-reliefs. It does not record colour.

The subtle surface relief of paintings and other objects represents a growing area of interest in heritage conservation. Lucida data enables researchers to 'remove' the colour from the surface of an object in order to study, for instance, a painter's brushstrokes or the pounce marks on a cartoon that was once used to weave a tapestry. In the case of the tomb of Tutankhamun, it was through examination of Lucida data, which removed the distraction of the chamber's painted surface, that Nicholas Reeves was able to propose the existence of hidden blocked doorways within the tomb.

The hardware and software for the Lucida scanner were conceived and developed by artist and engineer Manuel Franquelo together with a team of artists, conservators and engineers at Factum Arte. Logistical support was provided by Factum Foundation.

Following pages: Detail from the upper part of the east wall of the Sarcophagus Room in the tomb of Seti I, showing 3D data (left) and colour data blended into colour registered over 3D (right).

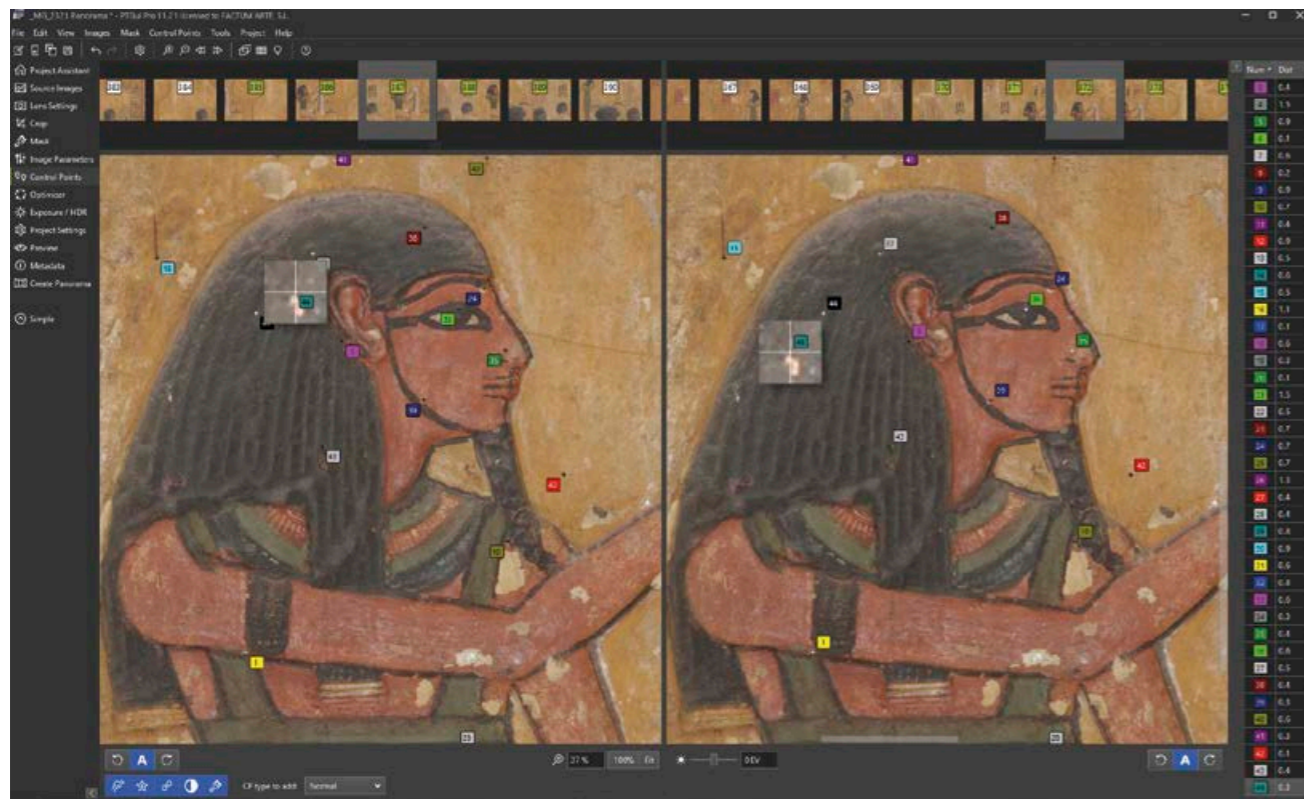
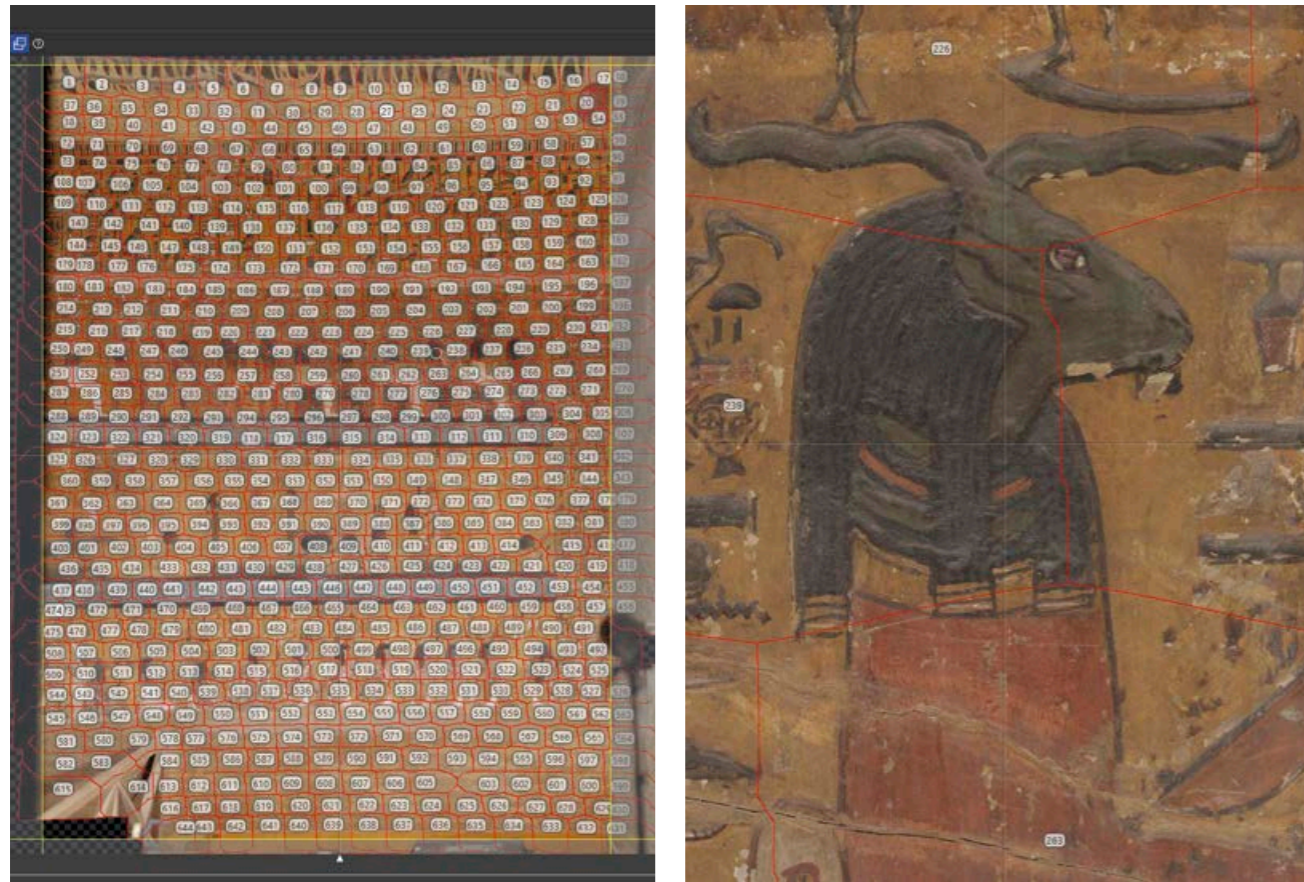




The celestial cow, Room Je.

Photogrammetry is a 3D recording technique that employs 2D images to create a 3D model of an object or surface. It involves taking hundreds of overlapping photographs of an object from many different angles and processing them into a 3D model using specialised software – the TNPI uses software developed by RealityCapture. The digital model can then be used for study or output as a physical object via 3D printing or CNC milling. Within the tombs in the Valley of the Kings, photogrammetry is used to record areas such as corners, niches or protrusions which cannot be recorded by the Lucida 3D Scanner (which requires a relatively flat surface). It has also been used to record fully 3D objects such as Seti's sarcophagus (in Sir John Soane's Museum) and the ushabtis and other grave goods from the tomb of Seti. Currently photogrammetry is being used on-site to record the 8,000 fragments from the tomb.

At a basic level, anyone with a camera phone can make a digital model using photogrammetry, but to make a high-resolution model – one which can be rematerialised as a facsimile, or even one which appears to have the same surface texture as the original object when viewed on-screen – the correct camera lenses, significant processing power and a precise methodology are necessary. Factum Foundation has developed photogrammetry to a level at which the data rivals that from high-level structured light and laser scanners, resulting in a portable, affordable recording method well-suited to recording in the Valley of the Kings.



Processing panoramic photography data. Above: Each numbered section in the top images corresponds to a different photograph taken on-site. The software automatically selects the most in-focus parts of each image to use in the panorama, with the red lines marking the new boundaries between images (top right). These are then checked and corrected manually, a process which can take weeks or even months depending on the size of the surface being digitised. Below: registering colour to 3D data using control points.

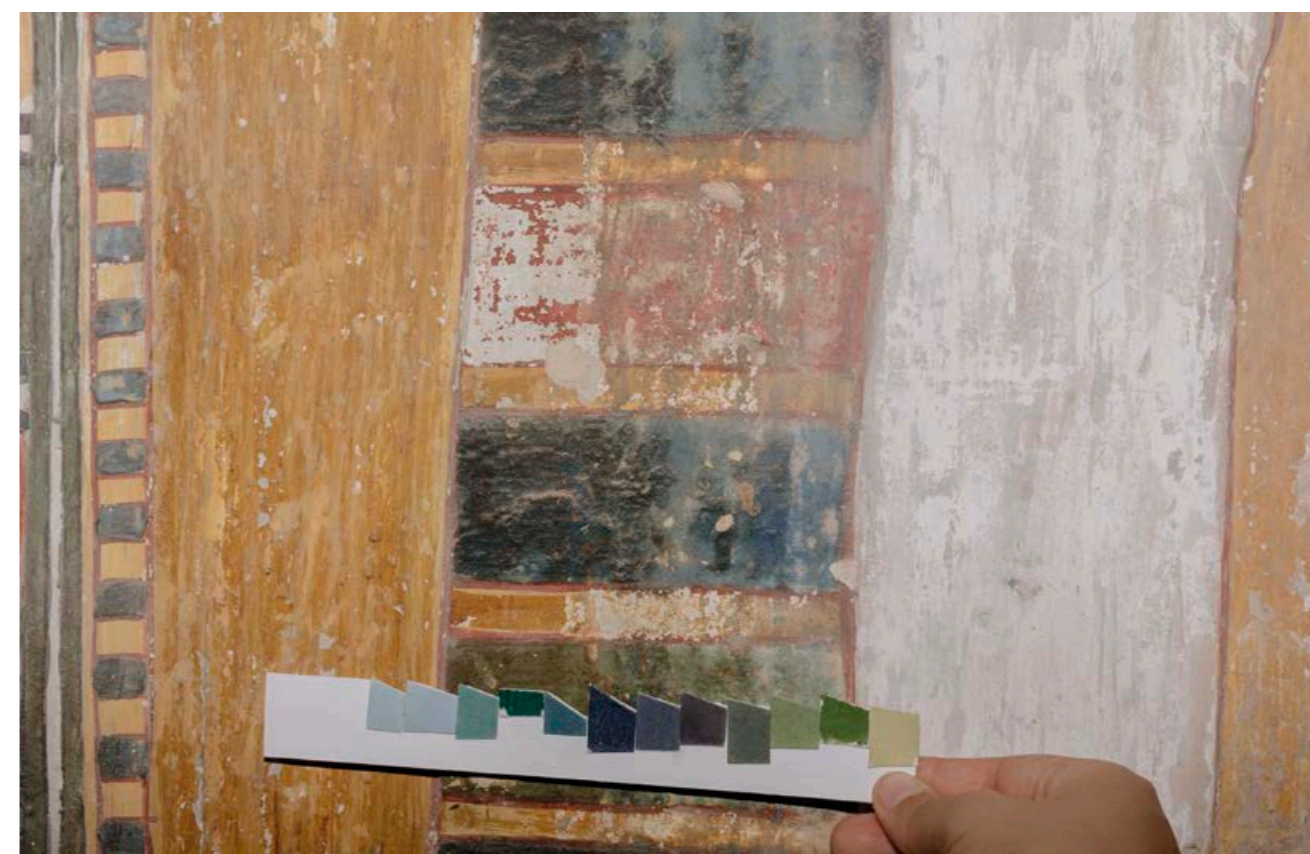
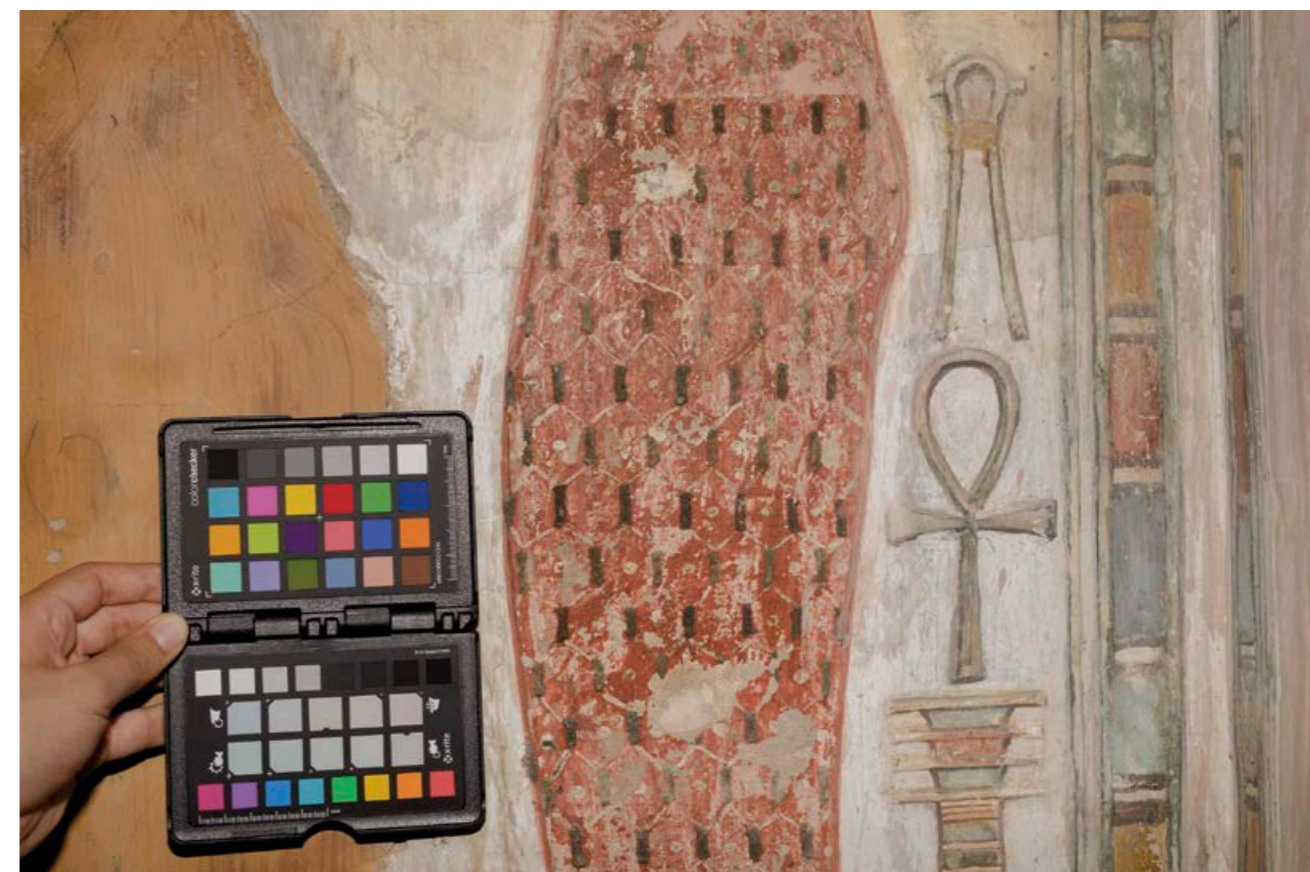
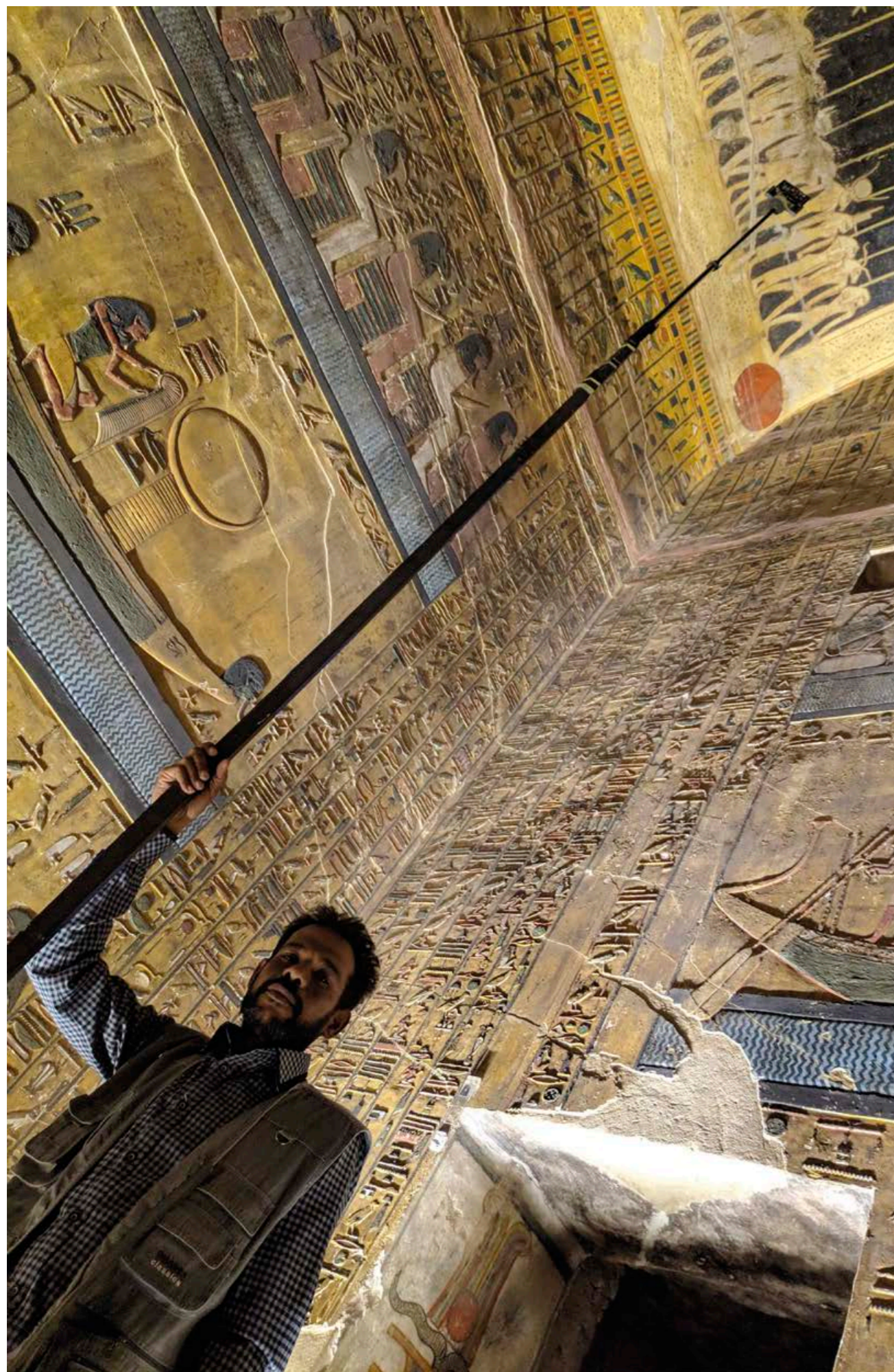


Conducting panoramic photography in the sarcophagus room.

Panoramic photography is used to capture accurate, high-resolution colour data for the tombs. Most people are familiar with the basic concept of stitching together multiple smaller photos to create a larger image, but the panoramas created by the TNPI and Factum comprise hundreds or even thousands of images, meaning that each tiny detail of a wall or ceiling appears in focus in the composite image. The colour data is subsequently laid over 3D data from the Lucida 3D scanner, creating digital images of the wall surface which even on a screen give a strong impression of 3D presence, preserving and enhancing the texture of the original surface.

Panoramic photography also allows the recording of accurate colour data. Colour is extremely difficult to record accurately, but by including an X-Rite colour checker with known RGB values within some of the photos recorded for a given panorama, it is possible to calibrate the recorded data so that any eventual printed colour will correspond to the original colour within the tombs. Factum Foundation has conducted extensive research in the accurate recording of colour, and the colour matching between the Foundation's facsimiles and their original referents is second to none.

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Colour checkers have to be held close to the surface being recorded, a process which can pose a significant technical challenge when recording high-up areas on a wall or ceiling.



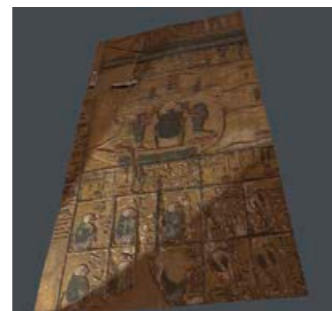
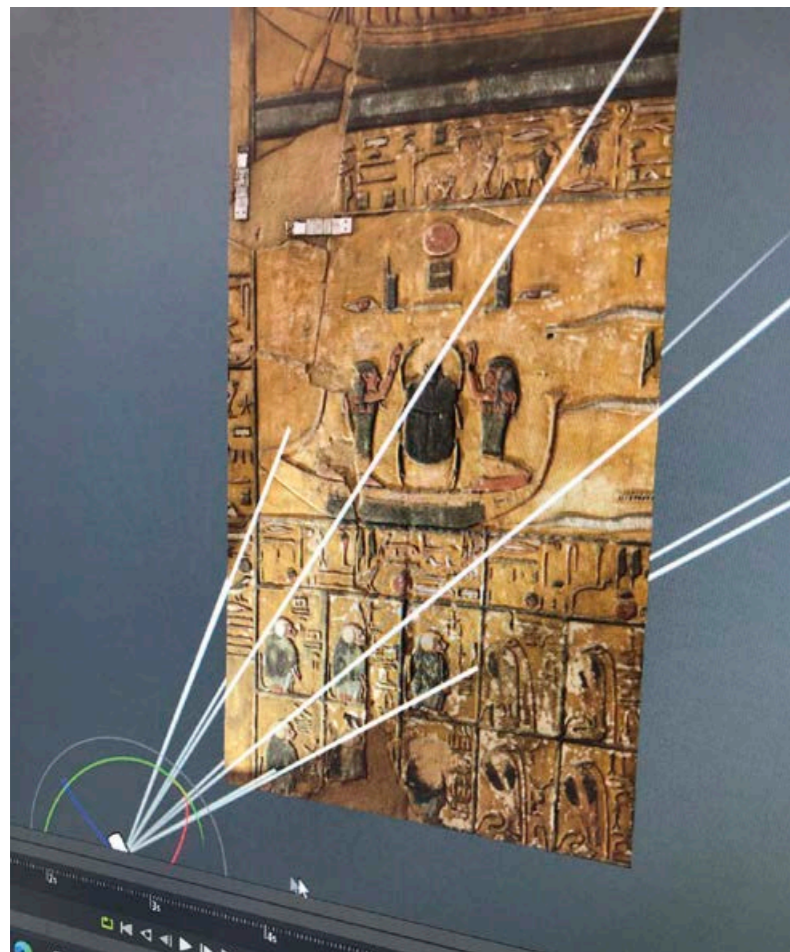
Colourised depthmap showing variation in relief on a recorded wall surface from the tomb of Seti.



DATA DISPLAY



Renders comprising 3D and color data from Room K in the tomb of Seti. Marmoset Toolbag 3 was used for real time rendering, creating the effect of light and shade. The data that has been recorded in the Tomb of Seti I since 2001 can now be visualised for the first time. With the release of the new 8K Unreal Engine software next year the experience will be better still.

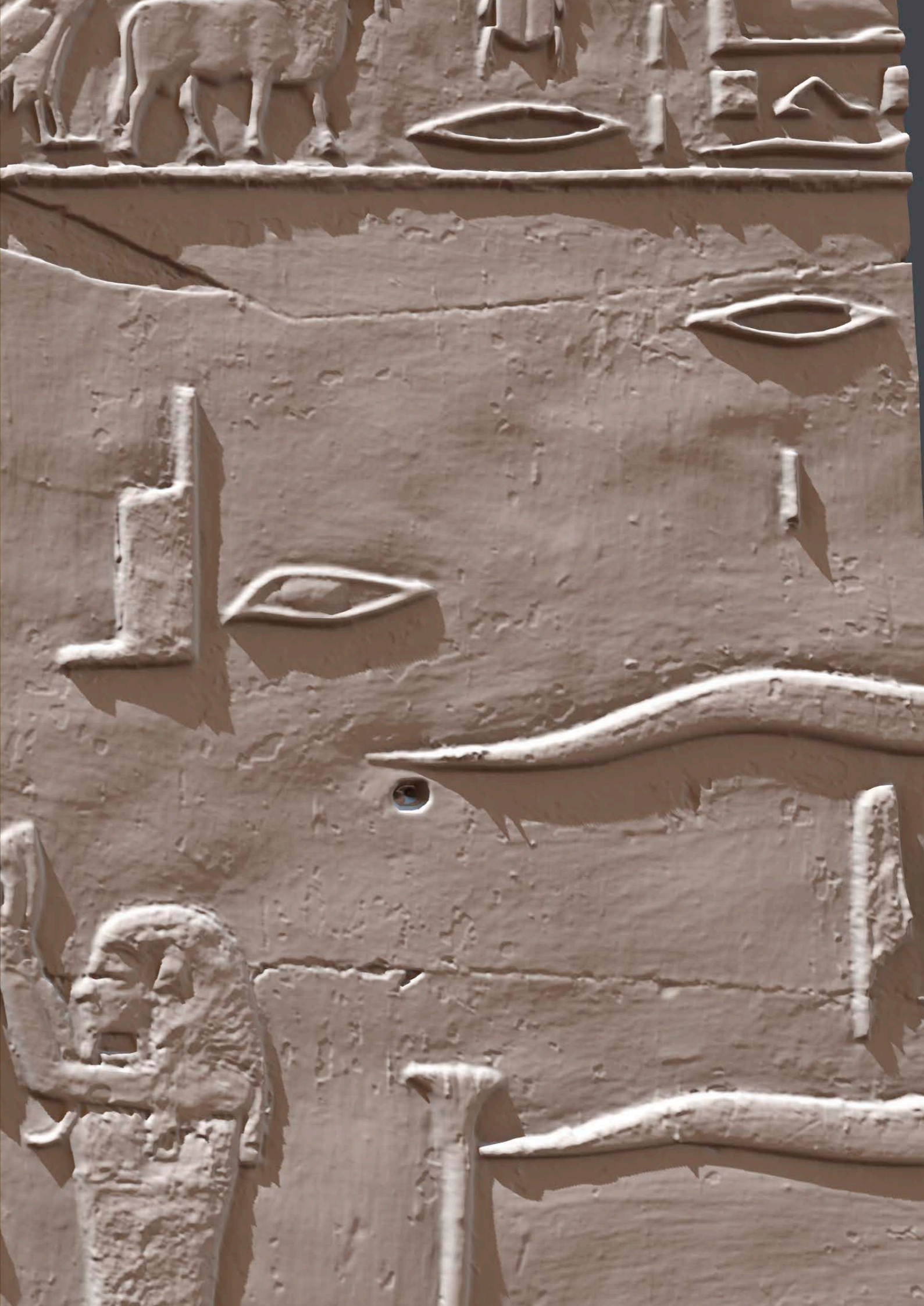


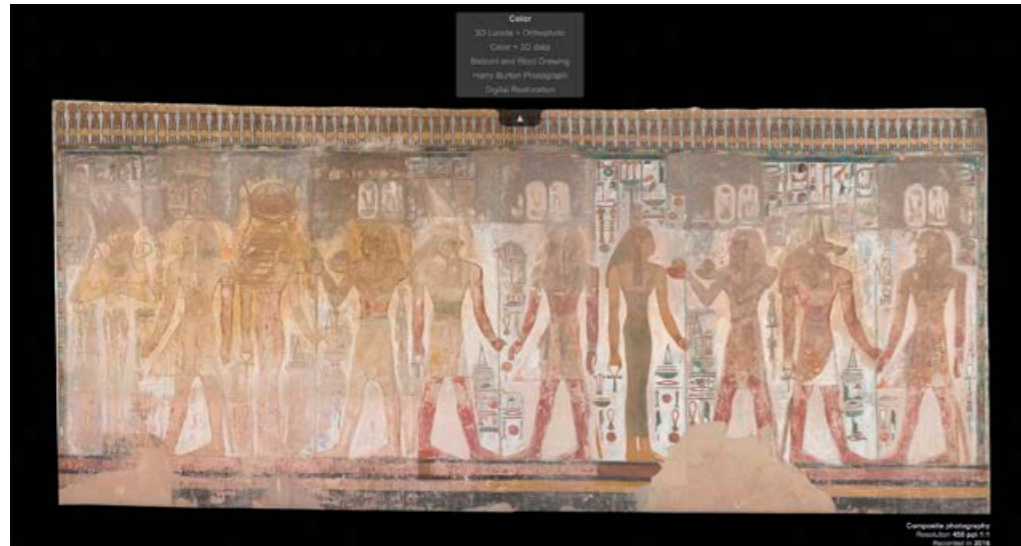
Setting a light source in Marmoset Toolbag 3. To create these high-resolution renders it is important that the 3D data is at the 100 micron level of resolution and the colour is recorded without highlights or shadows. The illusion of the light source is generated in real time in the software.

All of the data recorded by Factum Foundation and the TNPI is made available online, via easy-to-use interfaces compatible with ordinary home computers with good internet access. It can be used by those with a scholarly or professional interest in the tombs, by students in Egypt and around the world, or simply by virtual tourists seeking an escapist trip to a virtual Valley of the Kings. This online interest will create the next generation of actual visitors. Different display interfaces are used for different types of model – the low-relief surface of a stuccoed wall requires different treatment from the fully 3D rotatable model of a sarcophagus or statuette.

When we talk about data display, many of us automatically think of display on computer screens. But advances in processing and fabrication technologies mean that it is possible to rematerialise digital data in physical form as facsimiles and models. Mediated through lengthy and sophisticated digital processes, the facsimiles of Egyptian tombs produced by Factum Foundation and Factum Arte are among the most advanced forms of data display. They have an important role to play in exhibitions and museum display and complement the Virtual Reality, Mixed Reality and Augmented Reality applications that are emerging.

When Factum Arte first recorded data from the Sarcophagus Room (Room K) in the tomb of Seti I in 2001, recording technologies were more advanced than processing and display applications. Despite this, the Factum team recorded the tomb at the highest possible resolution, trusting that at a future point it would be possible to fully visualise the data recorded. Now, 20 years later, that hope has been realised, and the images on these pages show data recorded in RAW format, processed using Marmoset Toolbag 3. With the release of the new 8K Unreal Engine software next year the experience will be better still.

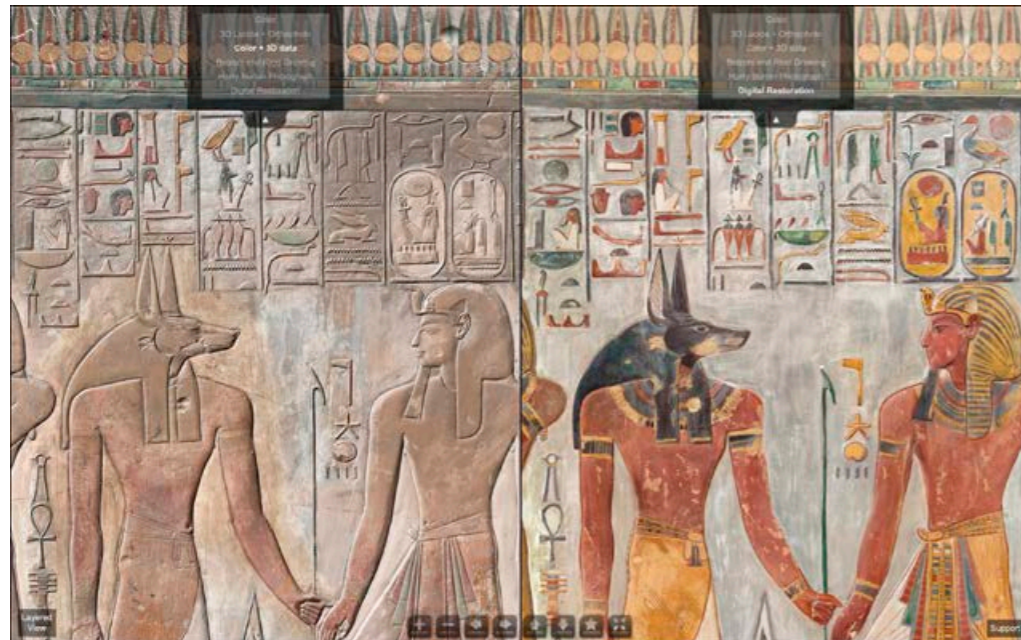




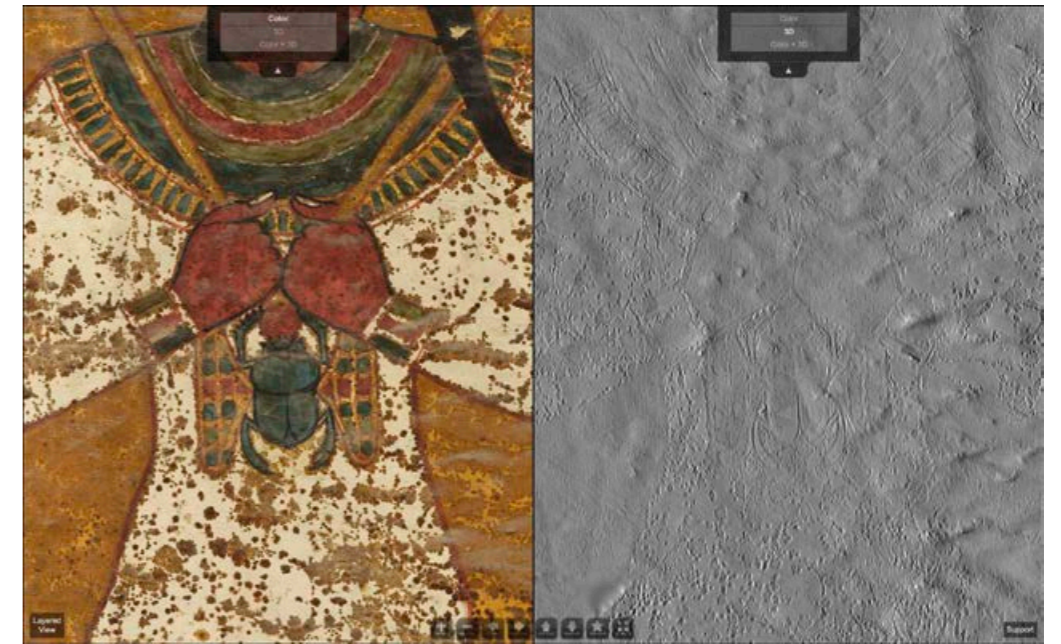
The layered browser of the Hall of Beauties in the tomb of Seti I.



Detail from the layered browser of the Hall of Beauties in the tomb of Seti I. Left: Photograph by Harry Burton from the 1920s. Right: drawing by Alessandro Ricci from the time of the 1819 discovery.



Detail from the layered browser of the Hall of Beauties in the tomb of Seti I. Left: the most recent TNPI recording, with colour + 3D data overlaid. Right: a digital restoration of the room to the condition in which Belzoni and Ricci might have seen it, before exposure led to fading of colours and loss of fragments.

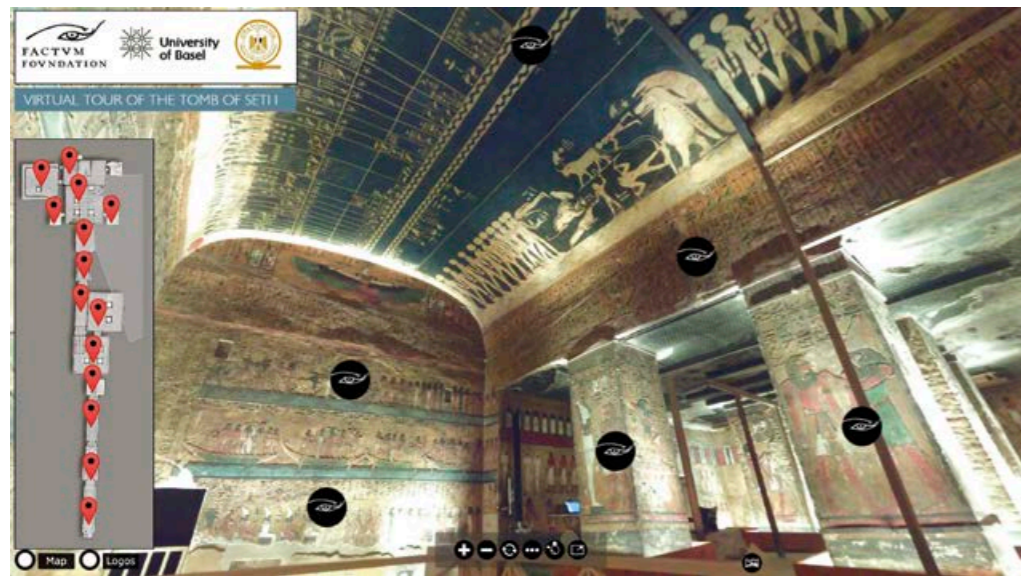


A detail from the burial chamber of Tutankhamun.

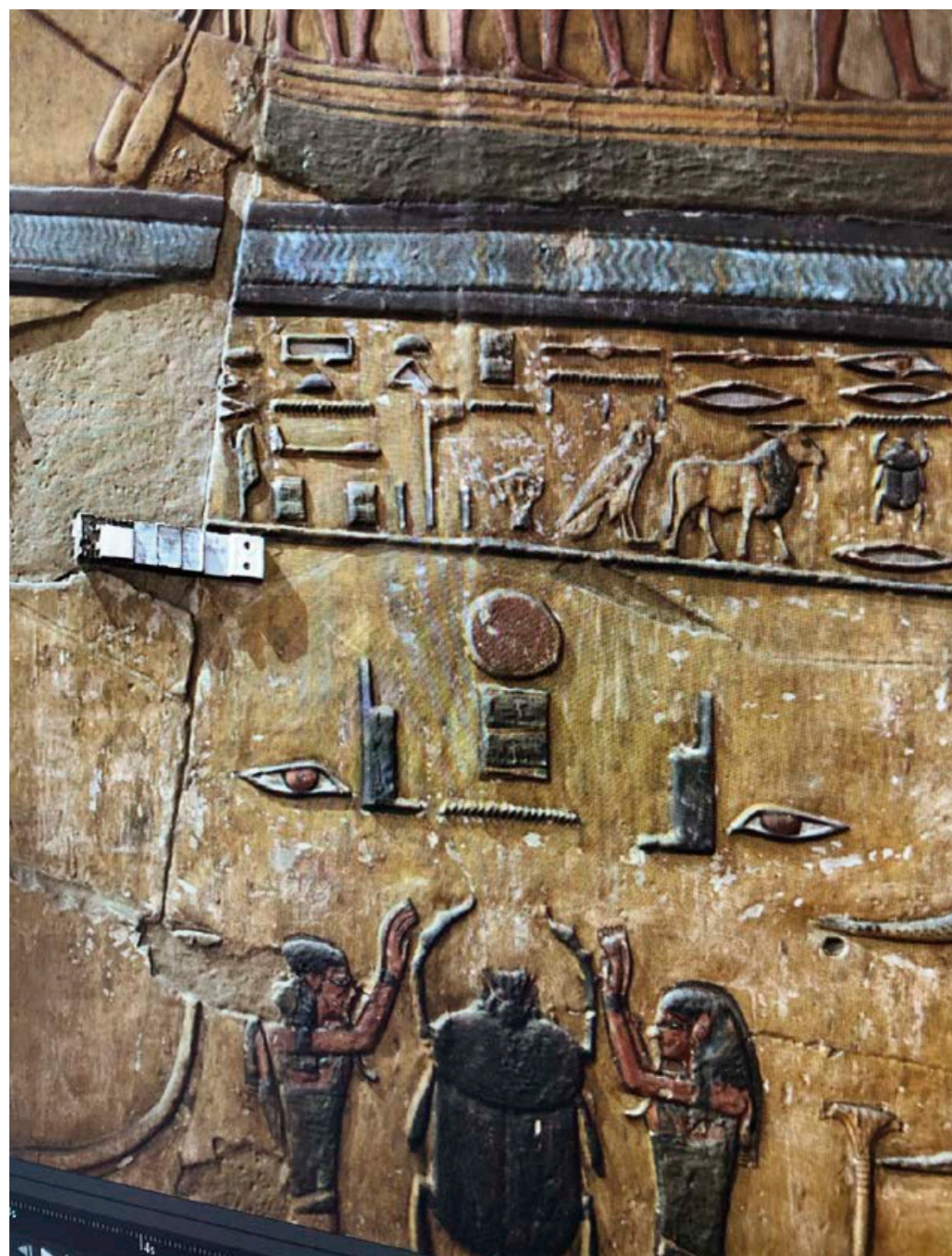


The interface for the recording of the burial chamber of Tutankhamun.

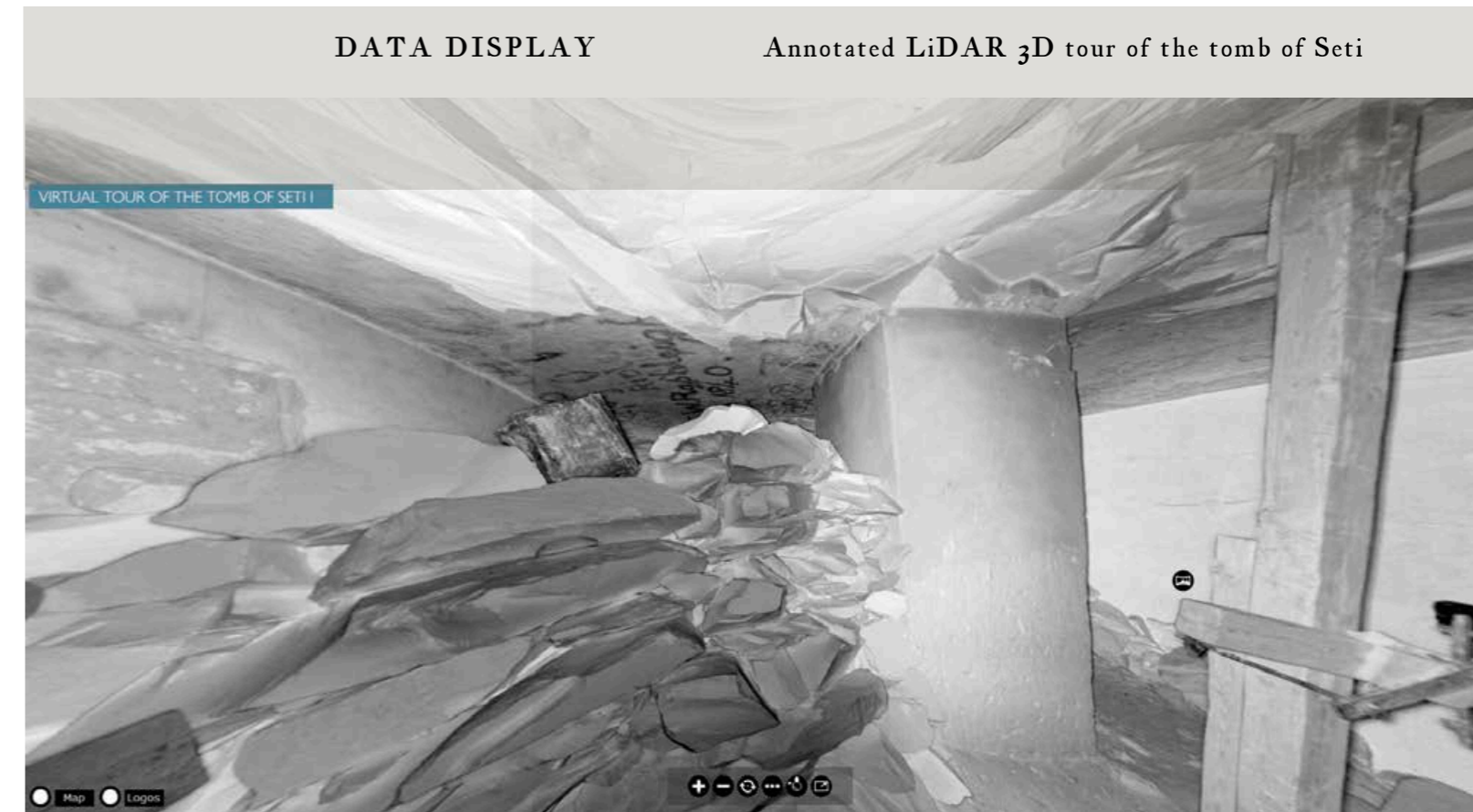
Factum's custom-made layered browsers allow different datasets to be examined up-close and easily compared with one another. Colourless low-relief from the Lucida 3D Scanner can be seen alongside colour data or as a combined image merging colour and relief. If the data is available at sufficient quality the browsers can contain multiple other layers, showing X-ray, IR, or ultraviolet recordings. For some of the rooms from the Tomb of Seti I, Factum's new data is even shown alongside Alessandro Ricci's watercolours of the tomb made after its discovery in 1819, and Harry Burton's photos from the 1920s. Informative and compellingly beautiful in equal measure, the browsers encourage detailed viewing of a sort never usually possible even for experts and those with privileged access to the tomb.



An annotated LiDAR view of the Sarcophagus Chamber in the Tomb of Seti I.



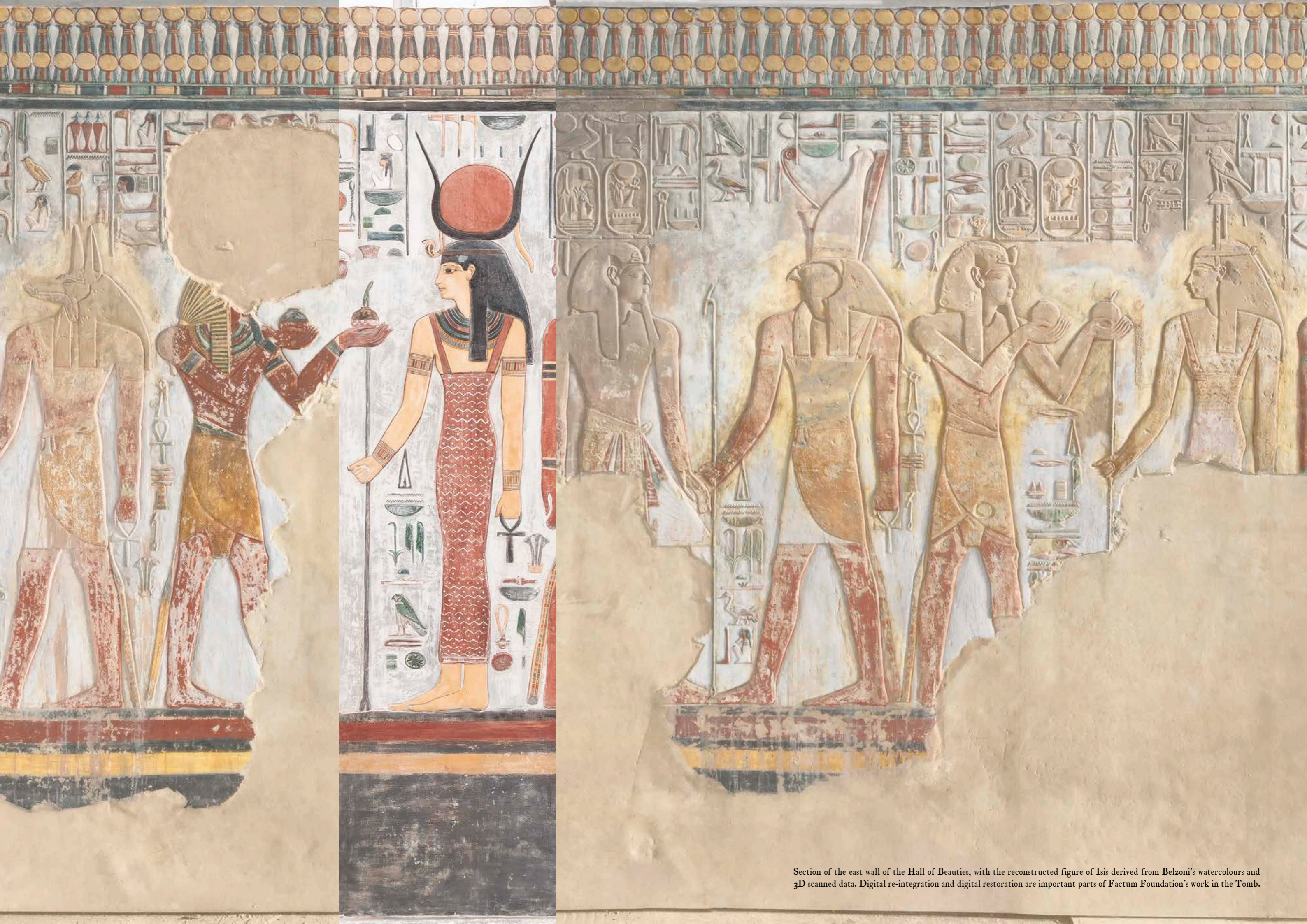
A render of the 3D and colour data from Room K. A complete virtual reality tour of the tomb is currently being developed.



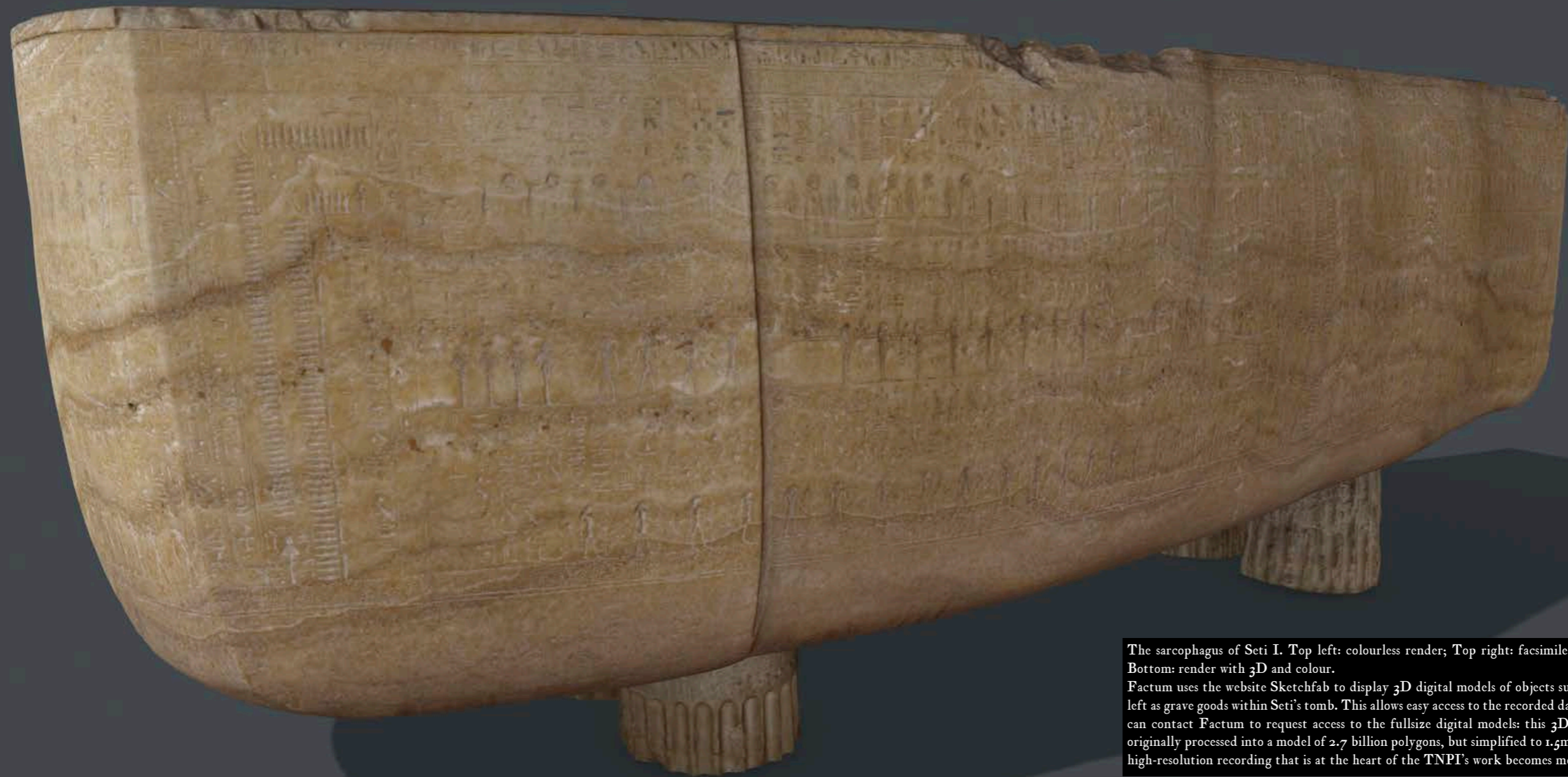
This small chamber off the Sarcophagus Room, which originally contained a mummified bull. It is still full of fallen rock and fragments which need to be studied and catalogued.

In 2020, Factum completed the first version of an annotated LiDAR 3D tour of the tomb of Seti I. This allows the visitor to navigate through a LiDAR scan of the tomb (recorded in 2016 – this will be re-recorded in 2021 at higher resolution), stopping at viewpoints along the way to access inset high-resolution layered browsers and information panels. The model acts as a dynamic archive, allowing far closer examination than any tour of the tomb would do – the spectacular ceiling in the Sarcophagus Room, for example, can be studied as if you were on scaffolding with the painting in front of your nose. It includes not only walls, ceilings and pillars, but also objects and fragments which are no longer within the tomb itself. The next step will be to incorporate into the platform the watercolours made by Giovanni Battista Belzoni, the Egyptologist who discovered the tomb in 1817 (now in Bristol City Museum), Harry Burton's black and white photographs from the 1920s (commissioned by the Metropolitan Museum in New York) and approximately 8,000 fragments from the tomb of Seti I, collected by the University of Basel, which are stored in the tomb of Ramesses X (KV 18) and are currently being analysed and relocated by Florence Mauric Barberio.

A complete virtual reality tour of the tomb is currently in development.



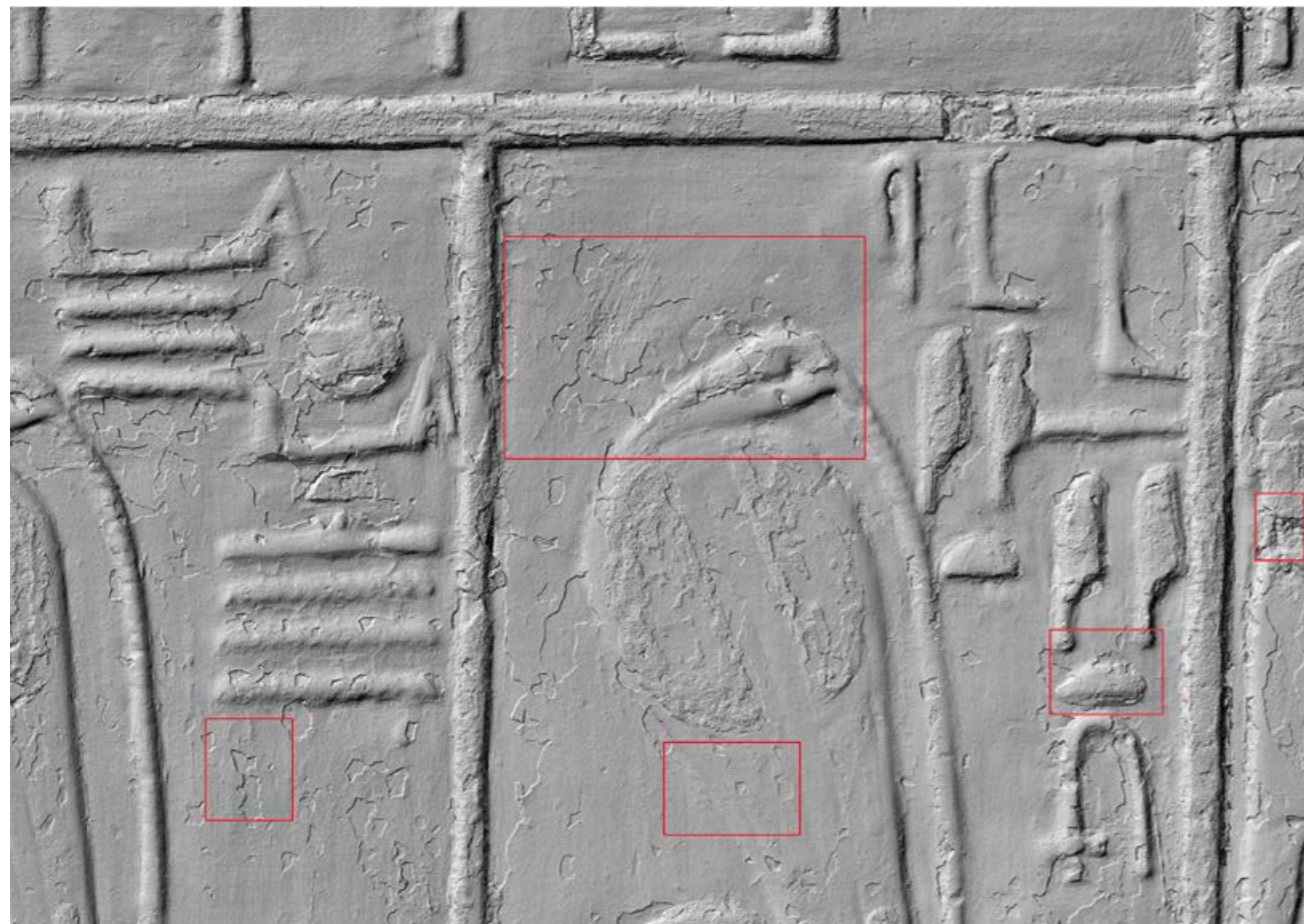
Section of the east wall of the Hall of Beauties, with the reconstructed figure of Isis derived from Belzoni's watercolours and 3D scanned data. Digital re-integration and digital restoration are important parts of Factum Foundation's work in the Tomb.



The sarcophagus of Seti I. Top left: colourless render; Top right: facsimile, shown at the 2017 exhibition *Scanning Seti*; Bottom: render with 3D and colour. Factum uses the website Sketchfab to display 3D digital models of objects such as the sarcophagus of Seti I and the ushabti left as grave goods within Seti's tomb. This allows easy access to the recorded data, although researchers seeking the full dataset can contact Factum to request access to the fullsize digital models: this 3D model of Seti's sarcophagus, for example, was originally processed into a model of 2.7 billion polygons, but simplified to 1.5m for display online. As technology develops, the high-resolution recording that is at the heart of the TNPT's work becomes more and more important.



Data from the east wall of Room K (the sarcophagus room) in the tomb of Seti I, recorded in 2001.



The same area recorded in 2019, with points at which deterioration is visible on the wall surface marked in red.

RESPONSES TO TNPI'S ONGOING WORK

Getty Conservation Institute and Carleton University

Every time a visitor enters Tutankhamun's funerary chamber, the 3,000-year-old walls deteriorate imperceptibly. Changes in humidity and temperature caused by the visitor's breath, sweat and body temperature mean that the painted plaster expands and contracts over the course of each day, and the dust which they bring into the room and circulate around it is so thick that it has to be wiped off the modern glass cover of the sarcophagus each morning. The dust is of different sorts: larger, granular dust which causes problems for scanners and computers, and fine powdery dust, difficult to remove, which settles on the walls, with a particular predilection for bulges or parts of the painted surface that are lifting away from the wall. Until a few years ago, dust used to be regularly vacuumed from the walls of Tutankhamun's tomb chamber, and in other tombs of the Valley of the Kings, conservation attempts using outdated methods have sometimes done more harm than good. Close inspection of the tomb reveals that there have already been significant losses which have been refilled and repainted in a way that mimics the brown dots of microbacteria. Different restorers use different styles, some splattering the paint, others using a brush to make the round marks.

One vital use to which the recordings of the tombs of Seti and Tutankhamun can be put is the monitoring of change in condition. Since the tombs were rediscovered, in 1819 and 1922 respectively, their condition has deteriorated significantly, but as this deterioration is gradual it is often difficult to spot the patterns of change until they are significantly advanced. The tomb of Tutankhamun has been recorded twice by Factum Foundation and the TNPI, in 2009 and in 2019. In the intervening decade, Getty Conservation Institute has carried out a major monitoring and conservation program in the tomb, which has included the removal of dust from the surface of the walls. The TNPI's data allows a definitive comparison of the state of the tomb at these two different points in time, making it easy to see where change has occurred. Thankfully, apart from the presence of less dust, the change is minimal (see images on the following page).

In a peer-reviewed article of 2019, L. Wong of the Getty Conservation Institute and M. Santana Quintero of the Carleton Immersive Media Studio, Carleton University, compare the Getty's own conservation program to Factum Foundation's 2009 recording and facsimile of the tomb chamber of Tutankhamun.¹ The paper acknowledges that: 'The Factum Foundation has done an admirable job in handing over files to Egyptian authorities, creating a digital archive, providing equipment and transferring technological knowledge of their process through training.' However, they suggest that it is a failing of the facsimile that Factum's recording captures the tomb at a single point in time – crucially, before the Getty had removed the dust from its surface:

'...despite the quest for accuracy, the tomb was documented in 2009, prior to its conservation, when the paintings were covered with dust. Since then the paintings have been cleaned as part of the conservation work. Based on the timing of capture, the replica now preserves for posterity a record not only of the painting, but also of the obfuscation of the paintings by dust. Accuracy here is time dependent and despite the technological advancements in recording and capture methods the resulting documentation produces a static record which captures a single moment in time.'

¹ L. Wong and M. Santana Quintero, 2019, 'Tutankhamun's Two Tombs: Replica Creation and the Preservation of our Cultural Heritage in a Digital Age' in *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences* (Volume XLII-2/W11, 2019 GEORES 2019). The paper was originally presented at presented at the 2nd International Conference of Geomatics and Restoration, 8–10 May 2019, Milan, Italy. It can be found at <https://pdfs.semanticscholar.org/e503/4c3eb6960b2cdf65bf70cfc8eed3fcc5fc9.pdf> (accessed 29 September 2020).



Data from the 2009 recording of the burial chamber of Tutankhamun before GCI consolidation and cleaning.



Data from the 2019 recording of the burial chamber after the GCI consolidation and cleaning.

Factum's policy is that we never touch the surface of an artwork, always recording the painted walls as they are. It is true that our 2019 recording shows significantly less dust than the 2009 recording, a valuable result of the Getty's conservation program. But the new recording is not entirely dust-free: already, a year after the conservation program ended in autumn 2018, dust had settled on the wall surfaces again. Other changes can also be seen (examples can be seen in the images on the previous page if you look carefully): there has been a slight deterioration of the surface over the last 10 years, including missing flecks of paint and slightly changed contours of pre-existing damage. Where the Luxor facsimile preserves the appearance of the tomb in 2009, future facsimiles can be based on more recently recorded data – the TNPI and Factum Foundation are currently in discussions with the Grand Egyptian Museum in Cairo over the production of a second facsimile based on the 2019 data. It is hoped that it will be possible to continue recording the tomb every 10 years, allowing ongoing monitoring of its condition.

Wong and Santana Quintero also write that there needs to be more dialogue between traditional conservation projects and digital conservation projects like that of Factum. The article ends as follows:

'How could the conservation approaches between these two projects in Tutankhamen's tomb been better aligned? Why was a decision made to create a replica and who was involved in this process? The current trend to record cultural heritage using 3D technology though offering many benefits can also overshadow other conservation needs. Instead, the use of 3D technology and the decision of whether or not to produce a replica should be seen and discussed as part of the larger documentation record and conservation strategy for a site.'

These questions have simple answers. There has always been ample scope to align these conservation approaches; in 2009, Factum Foundation offered to send the Getty Conservation Institute all of its recorded data from the tomb for use in their own project, and the Foundation has always made this data publicly available. Factum Foundation has also been working with the Carleton Immersive Media Studio at Carleton University, where Mario Santana Quintero teaches, for several years. We have welcomed two students to our Madrid headquarters as part of an in-depth collaboration, giving them access to engineering workshops and technical support that are not available at the university. Hopefully the Getty Conservation Institute will soon feel the need for collaboration and dialogue. It is important that the data is in the public domain where it can be studied and compared, and we are looking forward to seeing the photogrammetry carried out by Carleton University as part of the documentation of the GCI restoration. A direct comparison between this photogrammetry and the data recorded by Factum in 2009 and 2019 will be the first step towards a meaningful dialogue.

The Getty is correct that the TNPI does not conduct traditional conservation; this is not its aim. The TNPI's work focuses on accurate documentation and visualisation, online and offline, virtual and physical. We provide the data that restorers, conservators and scholars need, responding to their demands and working with them wherever possible. It was Factum Foundation's online application, a viewing system that allows colour and 3D recording to be seen separately or merged together, that led Nicholas Reeves to publish his first paper on the possible existence of another chamber behind the North Wall of the tomb in August 2015 (discussed elsewhere in this report).



2009 data. Spot the painted spots mimicking microbacteria.



2019 data. The slight difference between the 2009 and 2019 photographs does not mask the reappearance of dust.

More broadly, the facsimile in the Valley of the Kings has always been treated as part of a larger conservation strategy. The TNPI is uniquely embedded within local – as well as international – conservation and heritage networks. We were commissioned to undertake the recording in the tomb of Tutankhamun in 2009 by Zahi Hawass and Mustafa Wasiry, and all of our data belongs to the Egyptian Ministry of Tourism and Antiquities for all current and future commercial applications. The project as a whole has led to the training of a local team of cultural heritage digitisation specialists – a major step forward for conservation within the Valley of the Kings and Egypt more broadly.

For Egyptian cultural heritage professionals, Factum's facsimiles offer an important complement to the work of conservation initiatives such as the Getty. They create awareness among visitors to the Valley of the Kings of the fragility of these tombs and the ways in which they can contribute to their preservation. In the case of the proposed new GEM facsimile, they would make it possible for the grave goods from Tutankhamun's tomb to be seen in the same place as the (recreated) walls of the tomb itself for the first time since the tomb's excavation in 1922.

We look forward to working with the Getty Conservation Institute and with Egyptian local and national authorities to protect this extraordinary site of world heritage and at the same time to make it as easy as possible for audiences, scholars, curators and conservators in Luxor and worldwide to experience, enjoy and analyse the tomb of Tutankhamun, the tomb of Seti I and hopefully other tombs as well.



The north wall of the tomb, which was altered at the time of Tutankhamun's death to depict his funerary rites rather than those of Smenkhare, which were shown in an underlying composition.

RESPONSES TO TNPI'S ONGOING WORK

Nicholas Reeves' discovery
in the tomb of Tutankhamun

In 2014/2015, the Egyptologist Nicholas Reeves, examining the colourless 3D relief data from the burial chamber of Tutankhamun, noticed some unusual features that were not obvious when looking at the painted surface – either in the tomb or in reproduction. Following this evidence through, Reeves concluded that there was a distinct possibility that the wall paintings conceal at least two (potentially three) blocked doorways, and that the present small tomb complex is in fact a usurpation of the outermost section of a larger tomb – that of Nefertiti, the consort of Akhenaten, in her role as his pharaonic successor Smenkhkare. A decade after Smenkhkare's death, Reeves argued, the tomb had been reopened to admit the body of her stepson Tutankhamun.¹ The proposal received support from an observation of former Minister of Antiquities Mamdouh Eldamaty, that there was a difference in plaster texture – identical to that found on door-blockings removed by Carter – in the area in which Reeves had identified a doorway.

Despite initial widespread interest in the idea of new chambers stretching behind the walls of Tutankhamun's tomb, and a first ground-penetrating radar (GPR) study by Hirokatsu Watanabe which supported Reeves' proposal, further GPR studies by National Geographic and by Francesco Porcelli of the Polytechnic University of Turin failed to confirm the conjecture – with Porcelli even claiming that Turin's results disproved it. However, reprocessing of National Geographic's data by the independent specialist George Ballard has shown that 'the centre to east side of the Burial Chamber's north wall is not natural rock, but has been constructed;' and that 'beyond this thickness lay not a void, but a more varied material than either the natural, solid limestone or what is assumed to be man-made construction.'² As Ballard recognized, a possible explanation for these previous, indeterminate GPR results is that voids beyond the tomb had been backfilled, just as the entrance corridor of Tutankhamun had been when it was found by Carter – a common tactic to prevent graverobbers from entering or moving through a tomb. Intriguingly, a further GPR study, undertaken by Terravision Explorations in collaboration with Mamdouh Eldamaty and Ain Shams University in Cairo, has seemingly detected a subterranean space beyond this potential fill, to the northeast of the main burial chamber.³

In a third, forthcoming article published by the Amarna Royal Tombs Project, Reeves revisits his thesis, working with graphic artist Peter Gremse of ConzeptZone.de to confirm (using non-distorting computer animation) that the north wall scene which in its current, final form shows the burial of Tutankhamun by Ay (his successor as pharaoh) has indeed been altered – from a previous composition which showed the entombment of Nefertiti/Smenkhare by Tutankhamun.⁴

¹ Nicholas Reeves, 2015, *The Burial of Nefertiti?* (Amarna Royal Tombs Project, Valley of the Kings, Occasional Paper No. 1). Online at https://www.academia.edu/14406398/The_Burial_of_Nefertiti_2015 (accessed 24th September 2020).

² Ballard, in Nicholas Reeves, 2019, *The Decorated North Wall in the Tomb of Tutankhamun (KV 62) (The Burial of Nefertiti? II)* (Amarna Royal Tombs Project, Valley of the Kings, Occasional Paper No. 3): 18. Online at https://www.academia.edu/39903971/The_Decorated_North_Wall_in_the_Tomb_of_Tutankhamun_KV_62_The_Burial_of_Nefertiti_II_2019 (accessed 24th September 2020).

³ Jo Marchant, 19 February 2020, 'Is this Nefertiti's tomb? Radar clues ignite debate over hidden chambers,' *Nature*. <https://www.nature.com/articles/d41586-020-00465-y> (accessed 2 October 2020).

⁴ Nicholas Reeves, 2020, *The Tomb of Tutankhamun (KV 62): Supplementary Notes (The Burial of Nefertiti? III)*, (Amarna Royal Tombs Project, Valley of the Kings, Occasional Paper No. 5). Online at https://www.academia.edu/44309046/The_Tomb_of_Tutankhamun_KV_62_Supplementary_Notes_The_Burial_of_Nefertiti_III_2020.

When Factum Foundation posted their imagery and scans of Tutankhamun's Burial Chamber online in 2014, a detailed analysis of KV 62's architecture and decoration could be set in train at last. What this analysis revealed, a hundred years after the discovery, came as something of a shock: much of what we *thought* we knew about Tutankhamun's tomb was thrown into doubt; other features of the burial, newly observed, were almost too startling to contemplate.

These were not the first cracks to appear in the accepted view of things. A close examination of the tomb's contents had begun to yield its own extraordinary results a few years before. Most surprising of all was the recognition that Tutankhamun's burial was a sham: that the funerary items had originally been intended for someone else—a woman. The woman in question was Neferneferuaten—Akhenaten's co-regent, erstwhile queen, Nefertiti, and eventual successor, Smenkhkare—with the palimpsests of her co-regent's name visible still on the famous Gold Mask, canopic coffinettes and other items long accepted as Tutankhamun's own.

The contribution of Factum's data to this revised understanding would be a series of indirect pointers to the *location* of this woman's burial—astonishingly, within KV 62 itself. Not only do we now recognize the tomb's basic plan, with its diagnostic, right-turning corridor, to be that of a queen; a specific association with Nefertiti is indicated by repeat instances of what is demonstrably her image within an original decoration on the north wall—a decoration later reinscribed and adapted (though with the faces retained), to create the scene we see now, when the space that wall occupied was remodelled as a burial chamber for Tutankhamun.

Add to this indications of hidden doorways and a corridor continuation towards the north, and KV 62 stands revealed as but part of a larger whole: the later burial of Tutankhamun prepared within the outermost section of an earlier, more extensive tomb. This larger entity was undoubtedly the tomb of Nefertiti herself, the lady buried as Smenkhkare a corridor length and more beyond the north wall's camouflaging scene created to celebrate her interment; a scene—and this is key—which would have had absolutely no relevance within the burial of Tutankhamun himself.

The third instalment of Nicholas Reeves's The Burial of Nefertiti?—incorporating computer animations by Peter Gremse (ConceptZone.de) and explaining the major points of Reeves' argument—online at https://www.academia.edu/44309046/The_Tomb_of_Tutankhamun_KV_62_Supplementary_Notes_The_Burial_of_Nefertiti_III_2020: Reeves, Nicholas, 2020, The Tomb of Tutankhamun (KV 62): Supplementary Notes (The Burial of Nefertiti? III), (Amarna Royal Tombs Project, Valley of the Kings, Occasional Paper No. 5).



THE PARTNERS



All work undertaken by the TNPI is carried out under contract to the Egyptian Ministry of Tourism and Antiquities.

Factum Foundation:

The Factum Foundation for Digital Technology in Conservation is a not-for-profit organisation, founded in 2009 in Madrid. The Foundation is dedicated to the preservation of cultural heritage through the promotion of digital documentation, the production of facsimiles and sharing/archiving high-resolution files. Through research and collaborations, the Foundation is committed to the development of new technologies for heritage recording and re-materialisation. Factum Foundation trains technicians across the world in digital documentation. It is currently running projects in Egypt, Saudi Arabia, Dagestan, Italy, the US, Spain, the UK, Nigeria and Brazil. It has worked with institutions such as the National Gallery of Art (Washington DC), the National Gallery (London), the Museo del Prado (Madrid) and the Musée du Louvre (Paris). The Factum Foundation has designed and produced exhibitions for the Royal Academy (London), the Fondazione Giorgio Cini (Venice), Waddesdon Manor (Buckinghamshire, UK), Museo Arqueológico Nacional de Madrid, Palazzo Fava (Bologna) and the Antikenmuseum Basel.

University of Basel

Factum Foundation has been working with the University of Basel as its academic partner since 2009, originally with Erik Hornung, Professor Emeritus of Egyptology, and from 2015-2017 with Professor Dr Antonio Loprieno and Professor Dr Susanne Bickel. Since 2017 the main contact has been with Susanne Bickel, the director of the University of Basel Mission in the Valley of the Kings. Dr Bickel plays an important role in the selection of trainees, and remains in regular contact with the team in Luxor. Dr. Florence Barberio from the University of Basel team has also played a vital role, helped to locate and reassemble (in virtual space) the fragments that have been scanned from various Museums abroad. In March 2019 permission was received from the Ministry to scan about 8000 fragments found by the University of Basel team in and around the Tomb of Seti I. This collaboration will be a major addition to the scholarship relating to the tomb. In 2021 and beyond, it is intended that joint workshops and events will be held at Stoppelaëre house during the University of Basel Mission excavation season.

- 2001: Factum Arte begins work in the tomb of Seti I in collaboration with Dr Ahmed Baghat, Michael Mallinson, the University of Cambridge, and the SCA. Scan made of 16 sqm of wall in Room K. First meeting with Eric Hornung.
- 2001: First meeting with Theodor Abt and the Society of Friends of the Royal Tombs of Egypt. Presentation of the test facsimile of the burial chamber of Seti I at Museo Arqueológico Nacional, Madrid in collaboration with Museo Tifológico, Madrid.
- 2002: The production of the Facsimile of the Tomb of Thutmosis III.
- 2004 Video about Thutmosis with Eric Hornung and Theodor Abt with an introduction by Christian Loeben. *Las horas oscuras del sol* exhibition opens at Museo Arqueológico Nacional, Madrid.
- 2005 and 2006: Exhibition tours to Edinburgh and Basel.
- 2009: Formation of Factum Foundation for Digital Technology in Conservation as a not-for-profit charity registered in Spain. The recording of the Tomb of Tutankhamun begins on the instruction of His Excellency Dr Zahi Hawass with the backing of the Supreme Council of Antiquities (now the Ministry of Tourism and Antiquities).
- 2012: The facsimile is given to the people of Egypt by Baroness Ashton as a gift from the European Union and Factum Foundation.
- 2013: The decision to install the facsimile on the site next to Carter's House is taken by the Minister for Antiquities, Dr Mohamed Ibrahim in 2013.
- 2014: The didactic exhibition and facsimile are opened to the public on 1st May. The Factum Foundation for Digital Technology in Conservation is awarded Apollo Magazine's 2014 prize for 'Digital Innovation of the Year' for the work carried out to produce the facsimile. This approach to the preservation of at-risk cultural heritage in Egypt captures both the press and public interest.
- 2016: Extensive recording in the tomb of Seti I.
- 2017: Creation of a facsimile of two rooms from the tomb of Seti I (Rooms I and J) and the realisation of the exhibition *Scanning Seti* at the Antikenmuseum. Scanning of fragments in several European and American museums. The opening of Stoppelaëre House and the 3D Scanning, Training, and Archiving Centre.
- 2018: Finalisation of permission and security clearance.
- 2019: In February the TNPI restarts scanning work in Seti's tomb. The first two trainees arrive from the Ministry of Tourism and Antiquities to begin the new training program at the 3D Scanning, Training, and Archiving Centre. In October, the burial chamber of Tutankhamun is recorded in colour for a second time.
- 2020: Continuation of scanning in the tomb of Seti, despite interruption due to COVID-19 shutdown. Two new trainees accepted onto the training program. Initiation of the campaign to scan the 8000 fragments of the tomb still in the Valley of the Kings. Installation of the replica of the Djehuty Funerary Garden. Online publication of the first version of the annotated LiDAR 3D tour of the tomb of Seti.

FRAGMENTS FROM THE TOMB OF SETI I RECORDED OUTSIDE OF EGYPT

List of fragments scanned:

Museum of Fine Arts, Boston

- Reference 72.645ab; 300 x 200 mm
 Reference 72.646; 70 x 80 mm
 Reference 72.647; 160 x 140 mm
 Reference 72.649; 220 x 150 mm
 Reference 72.650; 100 x 40 mm
 Reference 72.651; 130 x 100 mm
 Reference 72.653; 180 x 180 mm
 Reference 72.661; 90 x 120 mm

Musée du Louvre, Paris

- Reference B7; 2260 x 1050 mm

Ägyptisches Museum und Papyrussammlung, Berlin

- Reference ÄM2058; 2610 x 880 mm
 Reference ÄM 2079; 1050 x 530 mm
 Reference ÄM 2079; 1060 x 540 mm

Museo Archeologico Nazionale, Florence

- Seti and Hathor; 2350 x 1030 mm
 Maat; 740 x 470 mm

British Museum, London

- Reference EA855 (Side A); 1660 x 630 mm
 Reference EA855 (Side B); 1660 x 200 mm
 Reference EA884 (Side A); 490 x 400 mm
 Reference EA884 (Side B); 490 x 210 mm
 Reference EA5602; 240 x 180 mm
 Reference EA5603; 250 x 240 mm
 Reference EA5604; 110 x 70 mm
 Reference EA5605; 130 x 100 mm
 Reference EA5606; 100 x 180 mm
 Reference EA5608; 280 x 200 mm
 Reference EA5610; 250 x 380 mm
 Reference EA35499; 80 x 110 mm
 Reference EA35500; 50 x 80 mm

Sarcophagus lid fragments

- Reference EA37928; 100 x 160 mm
 Reference EA29948; 350 x 240 mm
 Reference EA37927; 120 x 140 mm

Galerie Eberwein Ancient Art, Paris

- No reference number; 360 x 150 mm
 © Galerie Eberwein Ancient Art
 Relief fragment from the corner of a pillar in the sarcophagus chamber.

Sir John Soane's Museum, London

The entire sarcophagus housed in Sir John Soane's Museum has been recorded in high-resolution and replicated using cutting-edge technology. 18 fragments of the sarcophagus lid of different sizes have also been recorded. Two are presented in a glass case while the others are set into plaster and housed in four wooden cases with glass protection designed by Joseph Bonomi the Younger.

Museum of Archaeology, Bologna

8 Shabtis in the collection of the Museum of Archaeology from Seti's tomb have been recorded.

Many small fragments were moved from the Tomb of Seti I by both tourists and egyptologists. They come into the market fairly often and appear in the catalogues of dealers. One small fragment was found with the London dealer last year. This will be recorded soon. Our aim is to record all known fragments and reintegrate them into the digital archive and physical facsimile.



Ushabti from the tomb, now held in the Museo Civico Archeologico in Bologna.

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The TNPI team consists of:

Aliaa Ismail (Director)
Abd El-Reheem Ghaba (Assistant Director)
Mahmoud Abdellah (3D Scanning Technician)
Amany Hassan (3D Scanning Technician)
Mosa El-Sayed (Trainee)
Hagar Ahmed (Trainee)
Mina Fahim (Trainee)

Mahmoud Salem has left the team and is now focusing on his creative work as a sculptor. We wish him every success.



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