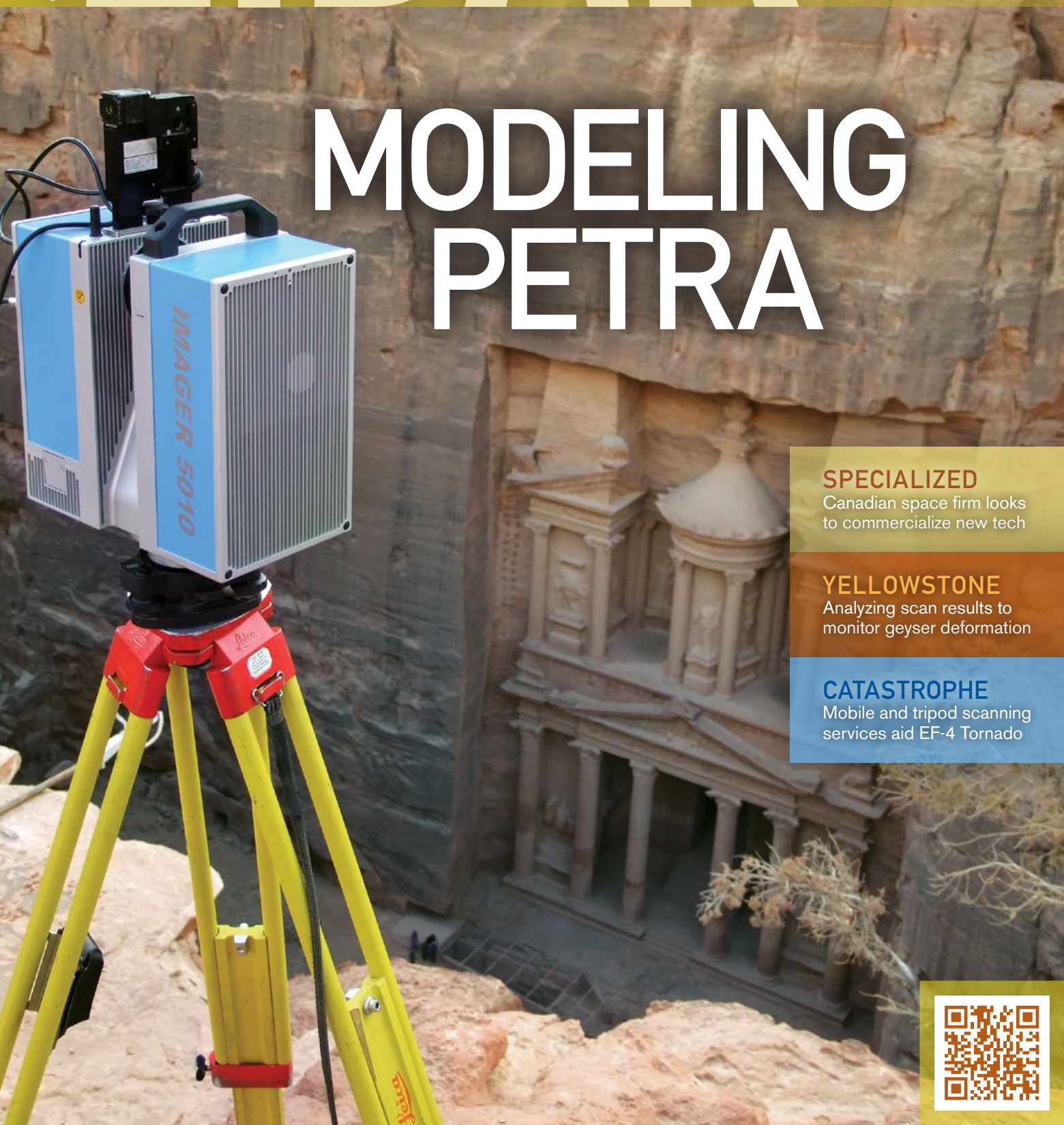
VOLUME 3 ISSUE 3

LIDAR



MODELING PETRA

SPECIALIZED
Canadian space firm looks to commercialize new tech

YELLOWSTONE
Analyzing scan results to monitor geyser deformation

CATASTROPHE
Mobile and tripod scanning services aid EF-4 Tornado

Al Deir (The Monastery).

Laser scanning Al-Khazneh (the Treasury).

Laser Scanning Africa's Heritage

Over the past eight years the "African Cultural Heritage Sites and Landscapes Database", also known as the Zamani project, based in the Geomatics Division of the University of Cape Town has documented more than 40 important African heritage sites in 13 countries. It is the objective of the documentation to create spatial data for restoration, conservation, education, research, site management and as a record for future generations. The documentation takes a holistic approach and comprises of high resolution 3D models of some 150 buildings, rock shelters, caves and monuments, derived from laser scans and photogrammetry. Elevations, sections, floor plans and ground plans are produced for each building.

A GIS and, where possible, a 3D terrain model for each site and its environment are created as well as panoramas and panorama tours. In addition to this there is a collection of supporting photography and videos, and references to relevant research articles. Extensive metadata are recorded for each site. The current dataset has a volume of close to 50Tb, consisting of presentation data, raw data and files generated in the processing stages. The raw data are retained to allow for future processing with new improved software.

Average scan and model resolution is 2 cm for buildings and 0.5 to 1 m for terrain. The data undergo a strict quality control including checks via comparison with GPS and conventional measurements.

BY PROF. HEINZ RÜTHER

On Top of the Siq.

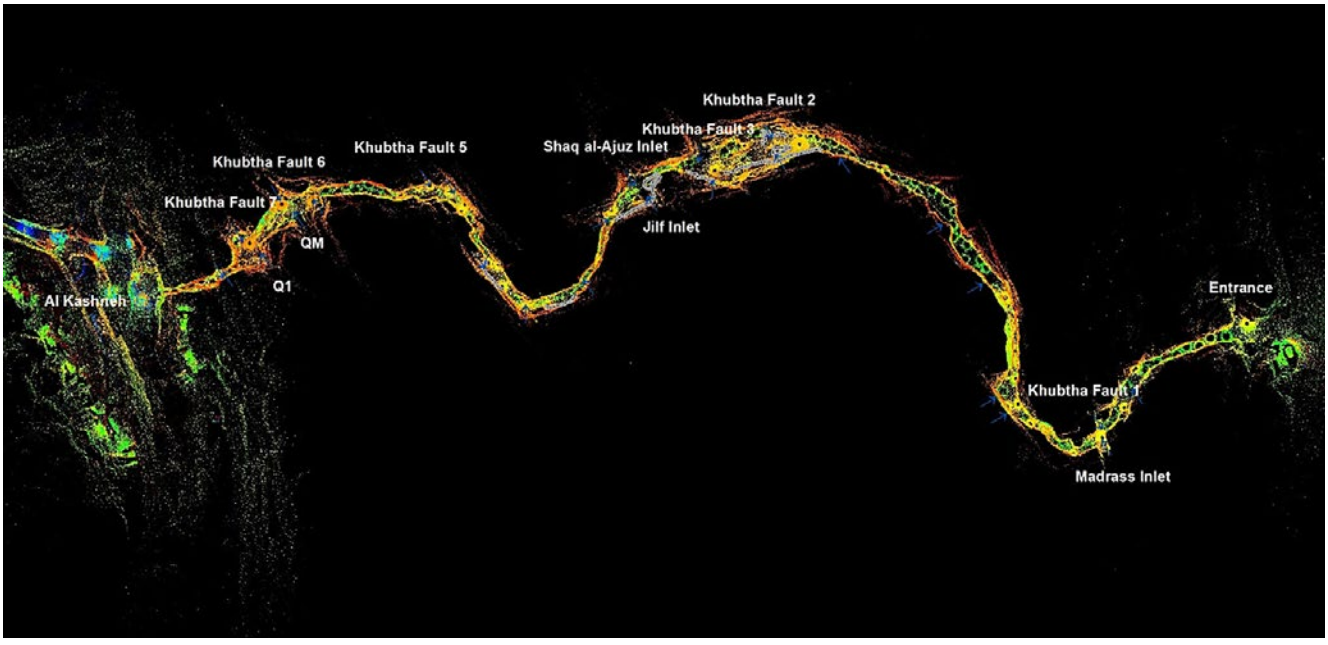
Giorgio Cesaro

Among the sites recorded to date are the UNESCO world heritage sites of Timbuktu and Djenne in Mali, Lalibela in Ethiopia, Great Zimbabwe in Zimbabwe, the Fortress on Mozambique Island, Kilwa in Tanzania, Elmina in Ghana, Stone Town on Zanzibar, and Robben Island in South Africa. Less known but similarly important sites are Engaruka in Tanzania and Namuratunga near Lake Turkana in Kenya, Diy-gid-biy in Cameroon and rock art in South Africa and Uganda.

Documentation projects were also carried out in the Valley of The Queens in Luxor and at the site of the Laetoli footprints in Tanzania for the Getty Conservation Institute, Songo Mnara in Tanzania for the World Monuments Fund and the Hili 17 site in Abu Dhabi for the Abu Dhabi Authority for Culture and Heritage.

The relevance of such documentation, especially in areas of war and civil unrest, has been highlighted by the recent occurrences of cultural terrorism in Timbuktu and Gao and it is likely that many more instances of destruction remain unreported. Climate change and sea level rising , as evidenced by the collapse of the seawall of the fortress in Kilwa, Tanzania and human impact further contribute to the loss of our heritage.

The African Cultural Heritage project was conceptualised in 2003 by Professor Heinz Rüther, Principal Investigator of the Zamani research group and is currently implemented with the support of three Scientific Officers, Ralph Schroeder, Roshan Bhurtha and Stephen Wessels. The team works in close co-operation with Christoph Held, former Zamani team member, now with Z+F in Germany. Every year four to eight interns from international Universities join the team. Additional interns are welcome to apply to heinz.ruther@zamaniproject.org.



Petra Siq pointcloud topview.

The Documentation of Petra

The current focus of the Zamani project is the UNESCO World Heritage site of Petra, located halfway between the Dead Sea and the Gulf of Aqaba in Jordan. Once a thriving centre of trade at the juncture of major trading routes, Petra was the capital city of the Nabataeans, a nomadic people whose empire rose to its peak between 400 BC and 100 AD. The site was listed as a UNESCO World Heritage Site in 1985.

Throughout their existence, the rock-hewn tombs, tricliniums and dwellings of Petra, as well as its freestanding palaces, colonnades and temples have been threatened by catastrophic events of earthquakes and floods and slow natural weathering through the forces of temperature changes, wind and rain. Today, the 2400 tourists who visit Petra, on average, every day add an additional factor to the multitude of threats facing the site.

An unusual challenge is the potential of slope instability and rock fall in the narrow access canyon to Petra, the so-called Siq. The Siq is 1.2 km long and 3 to 4 m wide in its many narrow sections. Its steep rock walls rise to 100 m and more. This challenge is addressed by the Siq Stability project, a project of the Italian Ministry of Foreign Affairs for UNESCO in co-operation with ISPRA (Italian Institute for Environmental Protection and Research), the Zamani Research Group, the Petra National Trust, Department of Antiquities of Jordan (DOA) and the Petra Development and Tourism Region Authority (PDTRA). The Zamani group is responsible for the

Textured 3D Model of Qasr al-Bint.

detailed 3D modeling of the Siq walls, based on terrestrial laser scanning and aerial photography, the creation of a comprehensive site GIS and database, a virtual tour, and the 3D documentation of the important tombs and structures as well a 3D model of the landscape of the two wadis.

To date the Zamani team has completed 1766 scans of Petra, produced 320 panoramas, acquired more than 3000 additional digital images and created a GIS of the Siq and the two main wadis of Petra, Wadi Musa and Wadi Farasa. The resulting point cloud comprises of some 12 billion surface points. The point cloud includes scans of the rock walls of the Siq, the outside and inside of some 30 major structures in the two wadis, including among others the famous Treasury and Monastery, the Royal Tombs and Urn tomb, the Soldier Tomb, the Garden Tomb, the Renaissance Tomb, the Amphitheater, Qasr al Bint and the Great Temple as well as the Bycentine church. All structures were fully scanned in very high detail (less than 1cm point interval) inside and outside and in some cases included underground tunnels. Also scanned were the general mountain terrain and much of the landscape surrounding the site.

In the narrow Siq scans were acquired at intervals of 10 m and less, with slightly increased distances between scan setups for the adjoining 1.1 km of the main valley with its many tombs and other manmade structures. The registration of the scans was achieved by first using a subset of some 300 scans to create a skeleton point cloud of 2.3 km length.

GPS points were established along the scan path, wherever possible, and the laser scan point cloud was transformed into the GPS points by means of a six-parameter transformation, i.e. three translations and three rotations, thus guaranteeing that the point cloud remained undistorted.

> "The Zamani project has documented more than 40 important African heritage sites."

At the outset of the project there were concerns that the error propagation of the registration through the over 2 km long, traverse-like sequence of hundreds of scans would result in significant errors. However, much to the relief of the team, the transformation revealed remaining discrepancies between the GPS co-ordinates and the co-ordinates of the same points in the point cloud of an average of only 6cm.

This registration accuracy was of special concern as the registration was based on ICP (iterative closest point) algorithms only, no targets could be used for a number of reasons. These excellent results not only confirm the high accuracy potential of laser scanning in heritage documentation, they support the Zamani team's approach to scanning, which does not rely on targets for registration. The team as a rule only uses targets for quality control where targeted points are captured as part of the point cloud and then surveyed by accurate GPS measurements and compared. The reasons for the choice of ICP over targets based registration cannot be elaborated here.

Once the encouraging results for the skeleton point cloud confirmed the quality of the acquired data, the remaining scans were registered against the skeleton and a surface model of the scanned area including all buildings is presently being created. The next months will see the completion of the remaining sections of Petra, the incorporation of the 3D models into the already prepared GIS and the creation of a virtual tour.

Credits

The African Cultural Heritage Sites and Landscapes Database was created with funding from the 'The Andrew W. Mellon Foundation,' New York and supported by the foundation until 2012.

Presently the project is funded through the "Zamani African Cultural Heritage Foundation", which was established by the Philanthropist and UCT Alumni ***Duncan Saville.***

Zoller + Fröhlich (Z+F), Optron/ Trimble, Leica Geosystems and Faro assist through the loan of equipment. The Zamani project enjoys ongoing logistical and other support from Z+F.

Professor Heinz Rüther is currently the Principal Investigator of the Zamani Research Group.