

# Recording architecture at the archaeological site of Uxmal, Mexico: A historical and contemporary view

by

Lawrence G. Desmond, Ph.D.  
Senior Research Fellow in Archaeology  
Mesoamerican Archive and Research Project  
Peabody Museum, Harvard University

and

Paul G. Bryan, BSc.  
UK National Delegate to CIPA  
Metric Survey Team Leader and Head of the Photogrammetric Unit,  
English Heritage, United Kingdom  
[paul.bryan@english-heritage.org.uk](mailto:paul.bryan@english-heritage.org.uk)

## Bibliographic reference:

Desmond, Lawrence G. and Paul G. Bryan  
2003 Recording architecture at the archaeological  
site of Uxmal, Mexico: A historical and contemporary view.  
In, *The Photogrammetric Record*, 18(102): 105-130,  
June 2003.

For the published version of this article contact:  
Blackwell Publishing, Ltd, Oxford, UK.

## Abstract

Architecture at the Maya archaeological site of Uxmal in Yucatan, Mexico has been documented since the 17th century by historians, archaeologists, illustrators, photographers, and most recently photogrammetrists. This paper reviews the work of the major contributors to recording of architecture at Uxmal with a particular focus on the 19th century stereo-photography of Alice and Augustus Le Plongeon who worked to record all the standing architecture at Uxmal, and the close-range stereo-photogrammetric projects that recorded the Adivino Pyramid during the late 20th century.

## Key words

Mexico, Uxmal, Maya, Adivino Pyramid, Pyramid of the Magician, archaeology, stereo-photography, documentation, Le Plongeon, Dixon, close-range photogrammetry.

I took stereopticon pictures of Yucatan in preference to single ones because they are more realistic when looked at with the proper instrument and they enable me to study the monuments as well, and sometimes better, than if I stood before them.  
Augustus Le Plongeon, 1902.

3D visualization systems with the ability to replicate touch and provide an immersive environment in which to view the data would also add an extra dimension to heritage work.  
David Barber, 2000.

## Introduction

The Maya archaeological site of Uxmal is located in the Yucatan peninsula of Mexico, (Figure 1) and at its height a thousand years ago had a population of about 30,000. The centre of the city is a complex of both religious and secular stone buildings decorated with sculpture, iconography, and hieroglyphics in what can only be described as a spectacular setting punctuated by the unique Adivino Pyramid (Figure 2). In 1996, Uxmal was inscribed to UNESCO's World Heritage List of Cultural Properties as a site "of outstanding universal value. The ruins of the ceremonial structures at Uxmal represent the pinnacle of late Mayan art and architecture in their design, layout and ornamentation..." (UNESCO 2001).

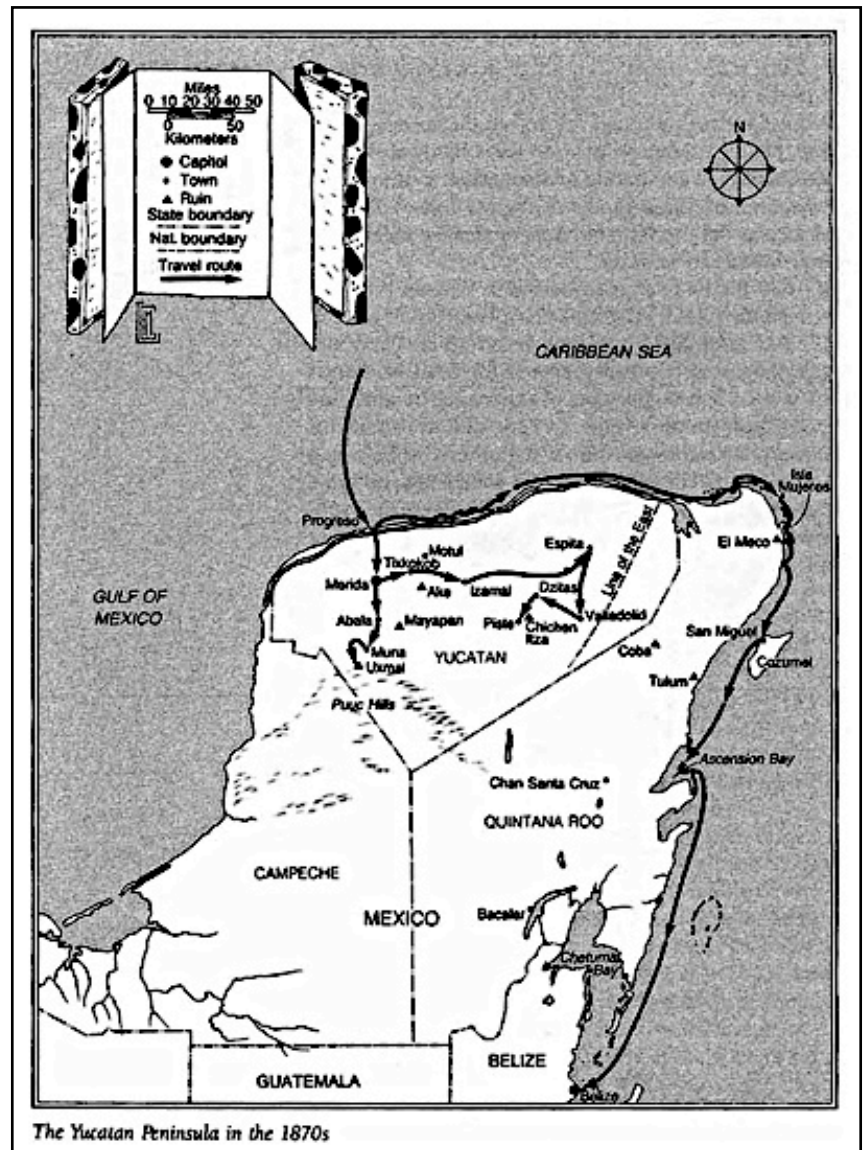


Figure 1. Map of the Yucatan Peninsula with the states of Yucatan, Campeche, and Quintana Roo. And, archaeological sites of Chichen Itza and Uxmal. Routes are those taken by Augustus and Alice Le Plongeon in the 1870s. Drawn by Lewis Messenger.



Figure 2. The Adivino Pyramid from the south. The Nunnery Quadrangle is to the west, and in the foreground is the House of the Turtles.  
Pic: L. G. Desmond, 1990.

### **Illustrators and photographers through the 1860s**

At the time of the Spanish invasion of Yucatan in the 16th century the rulers of Uxmal had already been driven from the city by competing Maya groups, and it was virtually abandoned. Military forces and travellers visited it, but it was not until the 17th century that an historical account of the city was written by the Spanish scholar Diego Lopez de Cogolludo.

In 1834, just prior to the use of photography, French explorer Jean-Frédéric Waldeck visited Uxmal and made a number of drawings of buildings (Waldeck 1838). His illustrations are a mix of artistic sketches and careful records of buildings. The historian Brunhouse states of Waldeck that his "aptitude was for art..." (Brunhouse 1974:79, and Baudez 1993).

Frederick Catherwood, a superb illustrator, draftsman and architect from London who had previously worked in Egypt, joined with the American travel writer John Lloyd Stephens in 1839 to explore the Maya ruins in Central America and Mexico. Catherwood used the camera lucida to assist him during that first expedition to draw Maya buildings at a number of sites in Honduras, Guatemala, and Mexico. Unfortunately, Catherwood became ill on their arrival at Uxmal, and they retreated to New York without carrying out any documentation. In 1841, they returned to Yucatan with Daguerreotype equipment and Catherwood attempted to photograph the ruins at Uxmal.

Stephens writes: "we had with us a Daguerreotype apparatus, the best that could be procured in New York, with which, immediately on our arrival at Uxmal, Mr. Catherwood began taking views, but the results were not sufficiently perfect to suit us" (Stephens 1843: Vol. 1:100).



Figure 3. Uxmal with the Adivino Pyramid on the right and Nunnery Quadrangle left. Drawing by Frederick Catherwood, ca 1840. Courtesy of Editara Sureste.

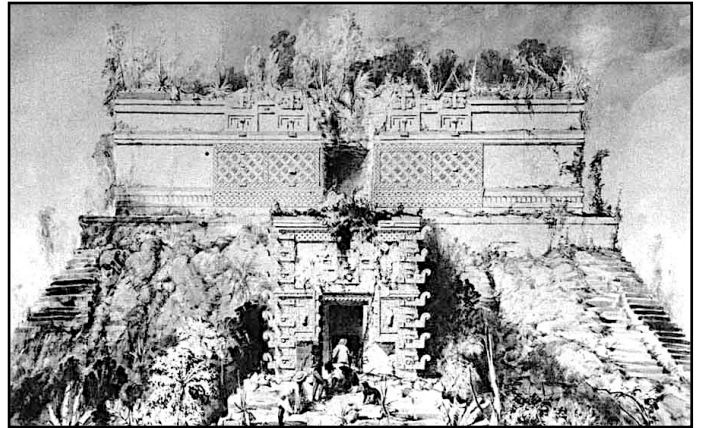


Figure 4. West façade of the Adivino Pyramid. Drawing by Frederick Catherwood, ca 1840. Courtesy of Editara Sureste.

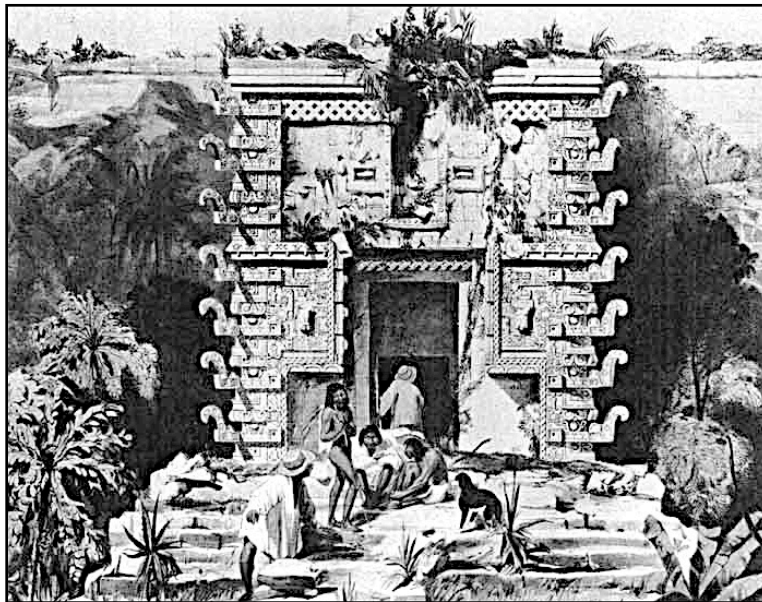


Figure 5. Chenes temple on the west façade of the Adivino Pyramid. Drawing by Frederick Catherwood., ca 1840. Courtesy of Editara Sureste

They abandoned the Daguerreotype and used the camera lucida to make drawings of the Adivino Pyramid and other buildings (Figure 3, Figure 4, and Figure 5) because "the projecting cornices and ornaments threw parts of the subject in shade, while others were in broad sunshine, so that, while parts were brought out well [in the Daguerreotype], other parts required pencil drawings to supply their defects" (Stephens 1843: Vol. 1:100). To publish such a drawing "would require more labor than that of making at once complete drawings" (Stephens 1943: Vol. 1:100).

In the 1860s the use of drawings gave way to photography when the wet collodion glass-plate negative became available to archaeologists and explorers. These negatives and the numerous prints that could be made from them did not replace the

hand illustration, but a good photographer could capture an enormous amount of architectural detail in a short time.

One of the earliest photographers to use glass negatives in Yucatan was Désiré Charnay, a French photographer and explorer, who in the 1860s documented buildings at a number of Maya sites, including Uxmal (Figure 6), using large format (15x21cm or 30x40cm) negatives (Charnay 1862-1863, and Davis 1981:205-206). His idea was to use the photographs to illustrate his travel writings, and to provide evidence for his theories about the Maya: "I wanted no one to challenge the exactitude of my work. Therefore I took photography as a witness" (Davis 1981:101).

The large glass plates used by Charnay provided equally large contact prints that could be sold, and were often used by expeditionary photographers during the 19th century to fund their work. Ironically, transport limitations in remote areas due to the weight and bulk of the large glass plates, the cumbersome camera, lenses, tripod, and all the darkroom equipment limited the number of photos that could be taken. While each image was carefully crafted, systematic and detailed documentation with large numbers of images in the remote tropical forests of Central America was virtually impossible.

It was not until the 1870s that the husband and wife team of Alice Dixon and Augustus Le Plongeon worked out a method for detailed and systematic documentation using large numbers of smaller stereo glass-plate negatives. This allowed much more thorough photographic documentation to be carried out at archaeological sites in the remote forests of Yucatan.

### **1870s and 1880s: Augustus Le Plongeon and Alice Dixon at Uxmal**

Augustus Le Plongeon

Augustus Le Plongeon (1826-1908) (Figure 7) was born on the Island of Jersey, and schooled in the sciences in France. He travelled to Chile, taught mathematics at a school in Valparaiso, and then in 1849, on hearing of the discovery of gold, sailed for San Francisco. While on a visit to England in 1861 he viewed a "demonstration of a new photographic technique...created by the photographer Fox Talbot" (Desmond and Messenger 1988:4), and returned to San Francisco to open a photographic studio.

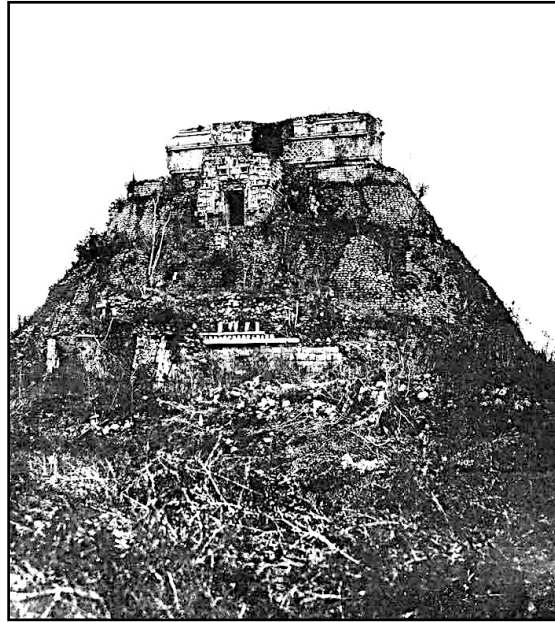


Figure 6. Photograph by Désiré Charnay of the west façade of Adivino Pyramid using the wet collodion glass-plate negative process. 1860. Collection musée de l'Homme, photo Désiré Charnay.

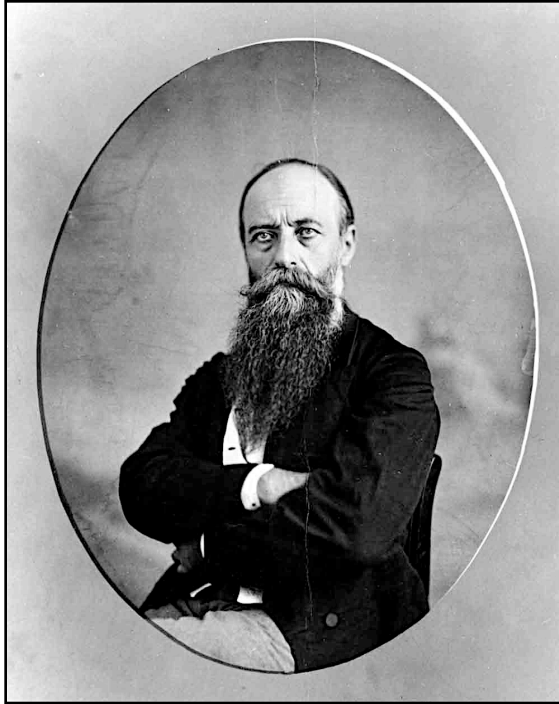


Figure 7. Augustus Le Plongeon, ca 1873. Photo by Alice Dixon Le Plongeon. Peabody Museum, Harvard University, Photo P2500B.

**MONS. PLONGEON'S**  
**DAGUERREIAN**  
**ROOMS.**

**The Daguerreotype Department**

Of this Establishment is managed by a skilful and attentive Artist, Mr. SILVEIRA. This gentleman has universally been fortunate in securing good Pictures, especially of

**INFANTS,**

Which he succeeds in taking in good style in TWO SECONDS.

**The Photographic Department.**

Daguerreotypes on paper is under the immediate supervision of Mons. Plongeon, who trusts that by giving his whole attention to that Department he will produce pictures unsurpassed in this city.

R O O M S :

**166 CLAY STREET,**

A few doors West of Montgomery, on the North side of Clay street.

Figure 8. Advertisement for Le Plongeon's photographic studio in San Francisco in 1856. From the San Francisco Business Directory, Baggett, Joseph and Company, Publications. 1856.

"The earliest known notice of Le Plongeon as a photographer was published September 15, 1855, announcing his purchase of the former gallery of William Shew at 166 Clay Street..." (Palmquist and Kailbourn 2000:365). (Figure 8)

From the beginning he was captivated by photography and wrote in the Photographic Times, "Photography since I learned its first rudiments from Mr. José Talbot, in 1852, has fascinated me, and has been to my mind a kind of enchanted ground" (A. Le Plongeon 1879:79).

In 1862, "Le Plongeon left San Francisco and moved to Lima, Peru where he began using the wet collodion glass-plate negative process for studio portraits, and to record t

he ancient ruins" (Desmond 2001:117). While in Peru he became intrigued with New World civilizations, read the works of the French Americanist scholar Brousseau de Bourbourg (Bourbourg 1857-1859), Waldeck's Voyage Pittoresque et archéologique dans la Province d'Yucatán pendant les années 1834 et 1836 (Waldeck 1838), and Stephens and Catherwood's Incidents of Travel in Yucatan (Stephens 1843), and decided to devote his life to studying Maya civilization. To prepare himself for his work in Mexico he travelled to London in 1871 to investigate Mexican manuscripts in the British Museum.



Figure 9. Alice Dixon Le Plongeon. Stains on her hands may be due to the use of silver nitrate, a photographic chemical. Photograph by Augustus Le Plongeon, ca 1873. Peabody Museum, Harvard University, Photo P2501B.

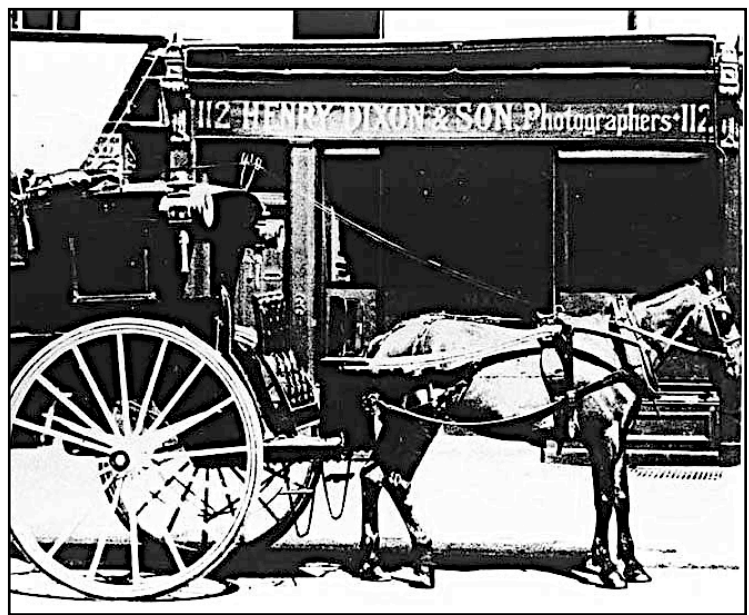


Figure 10. The photographic establishment of Henry Dixon & Son, 112 Albany Street, London. Photograph possibly by his son T. J. Dixon, c.1910. Courtesy of the Guildhall Library, Corporation of London.

## Alice Dixon

Augustus Le Plongeon met the photographer Alice Dixon (1851-1910) (Figure 9) during his trip to London in 1871. "As a young woman, Alice learned photography from her father Henry Dixon (1820-1893) who was a well known London photographer," and had assisted him in the family photographic business (Desmond and Messenger 1988:133). Alice's younger brother Thomas also joined his father in the photographic business in the 1880s, and continued to work as a practicing photographer until a few years before his death in 1943 (Figure 10).

Alice states her father had begun his work in photography early in the 1860s, and was very successful because, "[he] learnt very thoroughly steel-plate printing....to learn how pictures should look when rendered in black and white" (A. Dixon Le Plongeon 1890:648). "He was also one of the inventors of panchromatic photography" (Bush 1975:11).

In 1879, while Alice and Augustus were working to record Maya buildings in Yucatan, Dixon received a commission from the Society for Photographing the Relics of Old London to photograph "endangered and architecturally significant London relics..." (Foote 1987:134). The Society's reasons for documentation were to mitigate "The twin threats of abandonment and change" (Foote 1987:139). Dixon's carbon prints of London are today a priceless record of the old city, and are archived at the Guildhall Library, London Museum, George Eastman House, and the Gernsheim Collection of the Harry Ransom Humanities Research Center at the University of Texas.

## Planning documentation of the Maya ruins

In 1871, with the blessings of her family, Alice and Augustus sailed for New York. Prior to their departure, they discussed methods and techniques for photographing architecture with Henry Dixon, and those discussions contributed substantially to the success of their photographic work in Yucatan.

The Le Plongeons were motivated to document architecture in Yucatan for reasons quite similar to those put forth by the Society. For the *New York World*, Alice reported there were many endangered sites, and "The Peninsula of Yucatan is strewn with fragments of departed grandeur; silent, deserted, fallen cities. Some are not approachable without danger, lying as they do within the territories of hostile tribes. Others--and these are the worst treated--are in the power of the whites" (A. Dixon Le Plurgeon 1881b:2). Like Charnay, they were motivated by the knowledge that they would need photographs to backup any conclusions they might develop about the Maya, but they took documentation a step further and attempted to build a comprehensive photographic archive that would be useful for their research once they had returned to New York.

### Field equipment

Augustus, in a note in the *Photographic Times*, gave some details about the camera equipment he planned to take to Yucatan.

The expedition about to visit Yucatan has at its disposal Harrison's globe lenses - the same used during my explorations of the ruins of Peru and Bolivia; a pair of stereoscopic Harrison portrait lenses; Ross lenses (combination for portraits and views); Dallmeyer wide angle; Hermagis view lens; etc. (A. Le Plurgeon 1873:133).

The Le Plongeons' primary supplier of photographic equipment was the Scovill Manufacturing Company in New York. Scovill, with an eye to the Latin American photographic market, had already published Augustus' book on photography in Spanish, *Manual de Fotografia* (1873), which the editor of the *Photographic Times* reviewed in glowing terms as, "the best handbook of photography in the Spanish language" (A. Le Plurgeon 1878:232).



Figure 11. Scovill view camera similar to the camera used by the Le Plongeons. Single lens could be replaced by dual lenses for 3D stereo photos. Pic: L. G. Desmond, 1985.

As preparations were being made for their expedition, the Scovill company suggested Augustus make a test of their lenses before taking them to Yucatan. After the examination, Augustus replied, "I have compared carefully the relative qualities of them all [mentioned above] with the Morrison and have found the Morrison superior, with no



ghost, perfectly achromatic, lines mathematically true, and a perfect focus in every angle in which the camera may be placed" (A. Le Plongeon 1873:133). And so Augustus, "added an 11 x 4 Morrison wide-angle lens to the stock of the expedition..." (A. Le Plongeon 1873:134). His camera equipment (Figure 11) consisted of two view cameras for taking stereo images on 4 x 8 inch plates or single images on 5 x 8 inch plates.

To carry all the necessary photographic chemicals and other materials to make wet collodion glass-plate negatives, the Le Plongeon family devised a box in which a portable darkroom and all the photographic paraphernalia could be easily carried.

Before going to explore the ruins in Yucatan, Dr Le Plongeon invented a box in which everything could be packed in small compartments, and which could afterward be set up to serve as a darkroom, a sink and dark curtain also found a place in the box; and the apparatus could be put into working order by two people in less than five minutes. (A. Dixon Le Plongeon 1884:302).

The portable darkroom compacted much of their equipment which made travel easier, but the large glass-plates still presented a transportation problem. They needed to find a way to take hundreds of photos if they were to document the ruins at the level of detail they had proposed. Stereo photography was the answer, and was well known by the 1870s because of Sir David Brewster's book, *The stereoscope: Its history, theory and construction* (1856). Stereo images would allow the use of smaller negatives, and the Le Plongeon family taught themselves the technique of stereo photography. But, they still had to contend with the idiosyncratic process of the wet glass-plate negative process.

The Le Plongeon family hoped a new technology might replace the wet plate, and had heard that the dry glass-plate negatives being developed by Eastman and other companies could be processed long after exposure. Unfortunately, dry plates were not fully developed by their departure, so they decided to use wet plate 4 x 8 inch stereo negatives. In their opinion, the smaller negatives would be able to capture as much information for archaeological analysis as the larger glass plates, and the quality of the wet plate negative was superb, provided it was properly processed. The use of the smaller negatives considerably reduced the weight of their baggage, and so they packed hundreds for their photographic work in Yucatan.

When the "bromo-gelatine" dry plates became available during their expedition in Yucatan the Le Plongeon family tested them in the tropical environment, but the results were mixed:

Augustus:

In using them... we gain many things. Besides doing away with the dark tent, solutions and trays, and having to develop the plates in situ and immediately after exposure, we escape the danger of semi-crystallization of nitrate of silver... [A. Le Plongeon 1882:143].



Figure 12. Albrecht Meydenbauer's photogrammetric camera, c 1880.  
Pic: Paul G. Bryan, 2001.

Alice:

The introduction of gelatine dry plates has been a godsend to all who roam far from home... [but]...high temperatures of the air and water made it almost impossible to develop the negatives...ice would have worked but it was only available in Merida at twelve cents a pound and unheard of in the interior [A. Dixon Le Plongeon 1888:581].

During this same period in Germany, Albrecht Meydenbauer ([Figure 12](#)) had developed a photogrammetric method for the recording of historical buildings that allowed measurements and drawings to be made from photographic images. But, as dedicated as the Le Plongeon were to high quality documentation there is no mention of his work in

their writings. Augustus had been professionally trained as a surveyor, but it is possible that Meydenbauer's writings in German had not become widely known in the United States.

## Fieldwork

After making preparations during the Spring of 1873, the Le Plongeon sailed from New York to the port of Progreso in Yucatan in the early summer. They arrived at Progreso amid an outbreak of Yellow Fever, and rented rooms at the Hotel Meridiano in Merida. Within a few weeks Alice contracted the disease. Augustus, a medical doctor, helped his young bride fight the disease and she survived after a severe, week long battle with high fever.

After several months in Merida learning to speak Maya, and researching the archives, they were anxious to begin their fieldwork in order to see firsthand the Maya sites. They decided to visit Uxmal first, and then Chichen Itza. They put off going to Chichen Itza



Figure 13. Augustus and Alice Le Plongeon in the center room of the Governor's Palace. Note camera on table near Alice, surveying and photographic equipment. Photograph by the Le Plongeon, ca 1875. Archives of the Division of Anthropology, American Museum of Natural History, published with permission.

until a later date because few outsiders had succeeded in remaining for any length of time in the area because it was under the control of the Maya. An armed escort was needed for that expedition.

The trip to Uxmal was not particularly long or difficult. The road had been improved in the 1860s when the emperor of Mexico, Maximilian, sent Empress Carlotta on a diplomatic mission to Merida and Campeche. The Le Plongeon travelled at a leisurely pace to Uxmal, and photographed the villages and people along the way. At the town of Muna they made a panorama of the main plaza from a position near the colonial church by placing their view camera on a tripod and taking four joining 5 x 8 inch plates. This was their first panorama, and it was a technique they would soon use at Uxmal, and later Chichen Itza.

After their arrival at Uxmal, the Le Plongeon set up living quarters and a darkroom in the centre room of the Governor's Palace (Figure 13). It was a cool retreat during the heat of the day, but, according to Alice, not without insects, "The place swarms with life and perfect silence never reigns, for every tiny insect has something to say for itself" (A. Dixon Le Plongeon 1881b:2). The Le Plongeon seemed to thrive in the tropical environment taking in their stride bats flying in-and-out of their quarters, and insects that "feed on one...like a needle running in the flesh" (A. Dixon Le Plongeon 1881a:2).

Photographing the buildings at Uxmal using wet collodion glass-plates required preparation of each plate just prior to exposure first by spreading a thick solution of collodion over it, then sensitizing it by dipping it into silver nitrate. The plate was then placed in a light-tight plate holder and rushed to the camera atop a tall ladder for exposure before the collodion dried. After exposure the plate had to be immediately developed and fixed. To make matters even more difficult, the chemicals were often impure thus requiring a number of tests before they could be used.

The camera was heavy and had to be mounted on a very tall handmade tripod with a ladder for access (Figure 14). It had no shutter, and good exposures were made only by long experience and a thorough knowledge of the sensitivity of the chemicals and the quality of the light. Alice described the difficult camera work:

To make photographs of the ornaments on the edifices at Uxmal it was necessary to work from the top of a ladder...the ladder was so unsteady that, standing on it, breathing was enough to move and spoil the plate. So after drawing the slide [removing the slide to expose the wet plate] the doctor came down, and, by means of a long pole, uncovered and recovered the lens from below. The light changed during exposure, timing was impossible, and the plate was over exposed. Only after several attempts was a satisfactory result obtained [1884:303].

The Le Plongeons began their documentation by photographing the entire 320 foot east façade of the Governor's Palace with sixteen overlapping stereo photographs on 4x8 inch plates all taken at the same distance and height. The work may have taken as



Figure 14. Stereo photograph of Augustus Le Plungeon photographing the east façade of the Governor's Palace. Photograph by Alice Le Plungeon, ca 1875. Peabody Museum, Harvard University, Photo PM-59-50A.

much as two weeks since the angle of the sun to highlight the intricate motifs in a consistent manner was correct for only a few hours each day.

After the Governor's Palace they photographed the ornate stone facades of the Nunnery Quadrangle in stereo and with single plates using the same equipment and methods as was used to document the Governor's Palace. These facades are particularly important because they express the cosmology and astronomical learning of the Maya. From the top of the Adivino Pyramid the Le Plongeurs made a sweeping 180 degree panorama of the Nunnery Quadrangle and the rest of the site with stereo photographs.

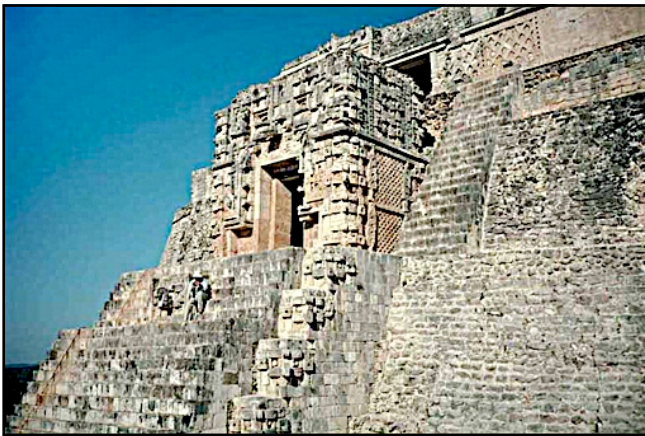


Figure 15. The west façade of the Adivino Pyramid showing the Chenes Temple, and a portion of the Puuc Temple above and behind. Pic: L. G. Desmond, 1999.

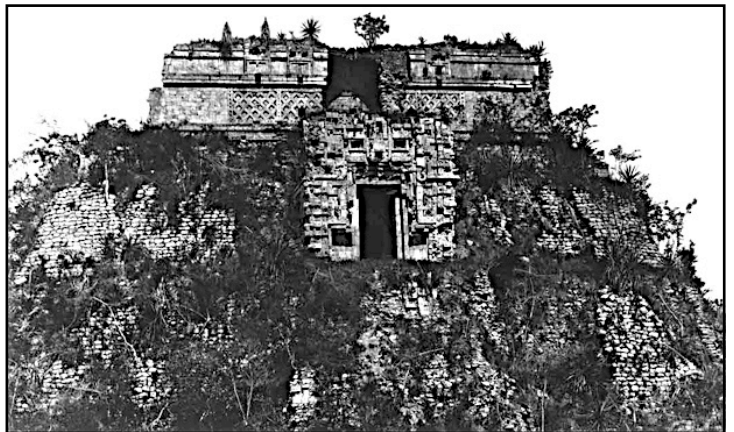


Figure 16. The Adivino Pyramid. Photograph by the Le Plongeurs, ca 1875. Peabody Museum, Harvard University, Photo P2506A.



Figure 17. Stereo photograph of the north façade of the Chenes Temple of the Adivino Pyramid showing the ladder from which Augustus Le Plongeon photographed iconographic details on the upper part of the temple above the doorway. Alice Le Plongeon is in the center of the photo. Photograph by the Le Plongeurs, ca 1875. Biblioteca Cepeda Peraza collection.

## The Adivino Pyramid

Then they began the difficult and dangerous task of recording the Chenes and Puuc style temples high on the west side of the Adivino Pyramid (Figure 15 and Figure 16). To photograph the iconographic low relief details on the Chenes Temple Augustus constructed a tall ladder and tripod on which to mount his camera for a straight-on, undistorted view (Figure 17). Alice recounts the difficulties:

The pictures of the west facade of the Adivino Pyramid at Uxmal were made at the risk of my husband's life. The foot of the ladder, which was about twenty feet high, was attached to two tree trunks just over the edge of its almost perpendicular side 100 feet high. The ladder was supported by two forked poles and held by ropes tied up in the room to two stone rings that once served to hang a curtain. The ladder was secure, but the danger to the doctor was consisted of any false motion or vertigo. Twice one day he was nearly sun struck and only able to continue by keeping wet cloths on his head [A. Dixon Le Plongeon 1884:303].

A bas-relief of two crouching figures high above the door to the Chenes Temple (Figure 18), shielded from view from below by a large stone Chac nose, presented an even greater challenge to the Le Plongeon. Alice describes the scene:

For one particular picture even the ladder was not high enough. After it was placed almost perpendicularly on the brink of the precipice, its top was not yet on a level with the object. A long pole was cut and planted at the base of the ladder. Then the doctor carried up his tripod, and tied the lower extremity of the legs, two to the top of the ladder, and one to the pole he had planted. It took a half hour to arrange it, and was a perilous and exhausting task, depending altogether, as the doctor did, upon standing steadily on a round stick, while his hands were busily employed. Owing to the dust and other petty annoyances, he had to make eight plates to obtain one to our satisfaction. [A. Dixon Le Plongeon 1884:303].



Figure 18. Stereo photograph of figures in bas-relief above the doorway of the Chenes Temple of the Adivino Pyramid. The location and lighting to make this superb photo clearly show that Alice and Augustus Le Plongeon were master photographers. Photograph by Augustus Le Plongeon, ca 1875. Biblioteca Cepeda Peraza collection.

The Le Plongeons do not explain if they set-up a temporary darkroom within the Chenes Temple or made innumerable trips up and down the pyramid carrying the still wet, exposed, glass-plates, but the images are of excellent quality.

### **Completing fieldwork**

After this first visit to Uxmal in 1873, they returned again in 1876 and in 1881 to make additional photos of buildings, bas-reliefs, and artifacts. Between their visits to Uxmal, the Le Plongeons spent two five month seasons at Chichen Itza in 1875 and 1876 systematically photographing the ruins and their excavations, and then five months again from the fall of 1883 to March 1884 photographing and excavating. They also made views of Yucatan and its people, photographed at the sites of Izamal, Isla Mujeres, Cozumel, Cancun, and Ake, and spent almost six months in Belize (British Honduras) where they took photos of artefacts, scenic views, and life in Belize. "By April 1876 he [Le Plongeon] reported that he had taken more than five hundred stereographic views in Yucatan" (Palmquist and Kailbourn 2000:366).

### **Post-field work**

They first returned to New York in 1880 with all their negatives and other research materials after almost seven years in Mexico and Belize. To protect their photographs they,

...resolved to make lantern slides, not only because we needed them to illustrate our lectures on the ruined cities of Central America, but because if any disaster happened to the negatives we could reproduce them at any time from the transparencies. For this work we used both Eastman's and Carbutt's dry plates, obtaining excellent results, though not often of crystalline transparency. We developed with ferro oxalate. (A. Dixon Le Plongeon 1888:582)

The Le Plongeons returned again to New York in 1881, 1882, and finally in 1884 they moved permanently to Brooklyn. But the transport of the glass plates was always hazardous. The emulsion was often damaged or the glass plates were cracked, so they copied the negatives, and the damaged parts could then be retouched. After making positive prints from the negatives...on Eastman negative paper, by contact [printing] from these... we reproduced negatives on paper...easily retouched with pencil... Now...I can print from these restored negatives. (A. Le Plongeon 1886:158-159)

### **The Le Plongeon legacy**

In New York they lectured using transparencies, and continued to write on Maya civilization using their photos to illustrate their books and they were involved with the New York community of photographers. On reading an article with the statement, "photography is not an art," the incensed Augustus fired back to the editor, "...there are

bad photographers, so there are bad painters... [but] Photography *is* an art, and photographers *are* artists..." (emphasis by Le Plongeon) (A. Le Plongeon 1885:495).

Augustus Le Plongeon died in 1908, and Alice Le Plongeon died two years later in 1910 at the age of 61. Their photos passed into the hands of a young friend named Maude Blackwell. Blackwell was instructed by the Le Plongeon family to destroy the photos if the American people did not show an interest in the Maya. Fortunately, archaeologist Alfred Kidder photographed the Maya archaeological site of Chichen Itza from a airplane piloted by Charles Lindbergh in 1929, and the photos were published in the New York Times.

For Blackwell this was a sign, and within a few months she contacted a number of archaeologists. After a long negotiation she sold part of the collection to Manly P. Hall, a philosopher and president of the Philosophical Research Society in Los Angeles. The remainder of her photographs were stored in a trunk in New York, and at the time of her death the trunk was forwarded to Dr. Gordon Ekholm at the American Museum of Natural History where the photos are currently archived.

Of the 795 Le Plongeon photographs and drawings now in archives, 156 are of Uxmal. The materials are curated at the Philosophical Research Society in Los Angeles, the American Museum of Natural History in New York, Getty Research Institute for the History of Art and the Humanities in Los Angeles, and the Peabody Museum at Harvard University, and consist of archaeological subjects, ethnographic photos of the Maya, landscapes, artefacts, and portraits. The four collections were catalogued by Lawrence Desmond, and duplicated for research use with funding from the US National Endowment for the Humanities in 1989. The duplicate collection is archived at the Center for Maya Research in Barnardville, North Carolina. [2015- Archived in the Wilson Library of the University of North Carolina-Chapel Hill.]

## **The 20th century**

In the 100 years following the Le Plongeon family, a number of outstanding individuals have worked to protect the cultural heritage of Mexico, and recorded the architecture at Uxmal and other sites in Mexico to very high standards. It is beyond the scope of this paper to provide a comprehensive review of them all, but we should note the very important work at the national level by Mexican scholars such as Manuel Gamio, Alfonso Caso, and Jimenez Moreno who, during the first half of the 20th century, developed governmental organizations and laws to protect and conserve not only Uxmal, but the entire archaeological heritage of Mexico.

We should also note the field and publishing contribution of Alfred P. Maudslay, a Londoner who photographed and surveyed many sites in Mesoamerica including Uxmal during the last years of the 19th century (Maudslay 1974); and Frans Blom of Tulane University who led a team that photographed and made moulds of the Nunnery Quadrangle in the 1930s (Blom 1932). Ian Graham, an archaeologist and epigrapher with the Peabody Museum at Harvard University, documented carved stone hieroglyphic texts at Uxmal (Graham 1992), but also throughout Mesoamerica using



stereo photography for more than 40 years. In the 1980s, art historian Jeff K. Kowalski carried out documentation and analysis of the iconography and architecture of the Governor's Palace at Uxmal (Kowalski 1987), and archaeologist Alfredo Barrera R. has worked at Uxmal since the 1970s to survey the site, and document and conserve the architecture (Barrera and Huchim 1990). Archaeologist Merle Greene Robertson has set a high standard for documentation of architecture at sites throughout Mesoamerica, including Uxmal, with photography, rubbings, and hand measured survey of buildings for more than 40 years. For her outstanding achievement of recording pre-Columbian monuments, the government of Mexico honored her with the Order of the Aztec Eagle, the highest award to a non-national (Greene 1967 and Greene Robertson 1995).

While photographic equipment and films have improved significantly during the past 100 years, and photogrammetry was used to document some architecture, the majority of New World documentation and archaeological projects continued to rely on 2D uncontrolled standard photography to document their work well into the 1980s. In Yucatan, that changed when a working link became established between archaeologists and photogrammetrists.

### **1989-1999: Close-range stereo-photogrammetry at Uxmal**

A link is established

Until the mid-1980s, close-range photogrammetry still remained an unknown technique for most archaeologists. In 1986 Thomas Beale, then with the Peabody Museum and American Schools of Oriental Research at Harvard University, published a paper on the use of stereo-photogrammetry to map the "surface of clay tablets only a few centimeters across and drawing individual Proto-Elamite signs... and making precise measurements of individual signs" (Beale 1986:11).

Beale was contacted by Lawrence Desmond, an archaeologist, who had proposed the use of photogrammetry to record Maya architecture in Yucatan. Beale suggested H. Del Foster, photogrammetrist and president of American Measuring Instruments, as a good source of information on the use of photogrammetry to record architecture. Foster had installed the stereoplotter used by Beale at Harvard's American Schools of Oriental Research, and had also used photogrammetry to record industrial and historic architecture in the United States.

After reviewing Desmond's proposal, Foster enthusiastically donated the use of a calibrated Bronica camera, and volunteered post-field lab support. While in-depth pre-field training was not possible, he did provide the project with basic guidelines for the photogrammetric recording of architecture.

Foster was also intrigued by the stereo photography of the Le Plongeon's, and requested a photo made by the Le Plongeon's in 1875 of La Iglesia building at the site of Chichen Itza. What drew his interest was that the Le Plongeon's had photographed the building shortly before part of its roof-comb had been destroyed by lightning. Foster

thought it was feasible to make a scaled drawing of the building that would include the missing roof-comb by applying current survey data to the 19th century stereo photo.

In 1989, as the survey of La Iglesia was being completed, archaeologist Ruben Maldonado, then director of Mexico's INAH (National Institute of Anthropology and History) Centro Yucatan, reported to the photogrammetry team at Chichen Itza that the Adivino Pyramid at Uxmal was seriously unstable, and that photogrammetric documentation was needed.

### The Adivino Pyramid: 1989 and 1990

In 1988, a few months before the Adivino photogrammetry project, a severe hurricane had caused structural destabilization of the west façade of the pyramid, and there was considerable worry that the façade might collapse. Quick action on the part of archaeologists with INAH prevented a catastrophe (Figure 19), but they saw that they had not completely solved the problem, and long range conservation planning was begun.

Maldonado needed an immediate photogrammetric survey of the west façade as a record should the façade collapse. The pyramid was documented at ground level with the calibrated Bronica photogrammetric camera provided by Foster, and surveyed with a transit theodolite (Desmond 1991 and 1994).

After the field work was completed, John Garcia, a photogrammetrist with American Measuring Instruments, made a 1:150 scale drawing on the west façade of the pyramid (Figure 20), and a drawing of La Iglesia including the missing part of the roof comb (Figures 21 and 22).

A second photo-grammetric survey of the west façade was organized by Desmond for 1990. University of Minnesota civil engineering professor



Figure 19. Emergency wood shoring within the tunnel under the west stairway. Shoring was later replaced by stone and concrete for greater stability. Note stairway separation from main structure in upper right corner. Pic: L. G. Desmond, 1989.

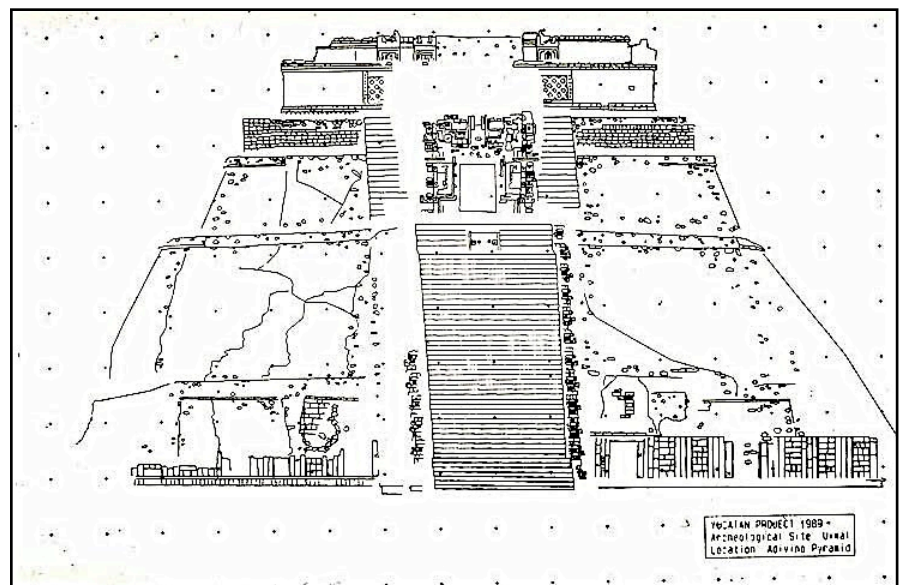


Figure 20. Scale drawing from 1989 photogrammetric survey data of the west façade of the Adivino Pyramid. Drawing by John Garcia, 1989.

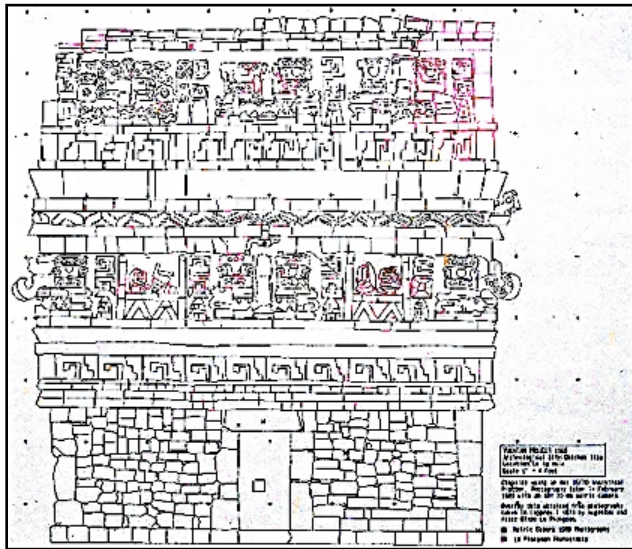


Figure 21. Scale drawing from calibrated 1875 Le Plongeon stereo photo of the roof comb of La Iglesia building at Chichen Itza. Drawing by John Garcia, 1989.

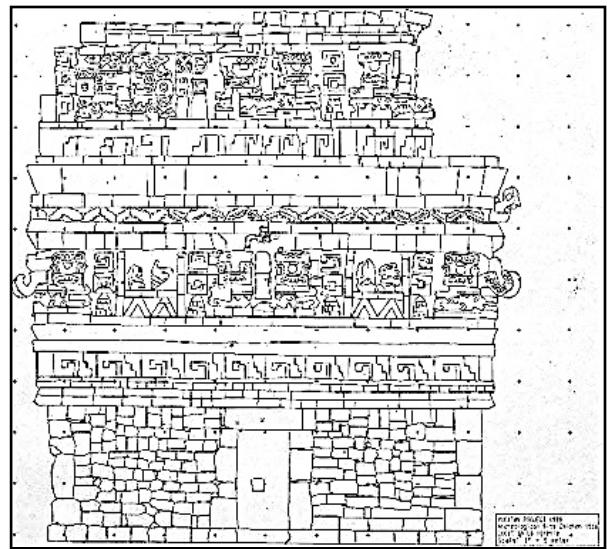


Figure 22. Scale drawing from 1989 photogrammetric survey of La Iglesia building at Chichen Itza. Drawing by John Garcia, 1989.

Gerald Johnson used a total station to survey the control targets, and the entire west façade was photographed again from ground level with a non-calibrated Hasselblad camera. A hydrogen balloon brought to Yucatan by Johnson was used to lift the camera high enough to photograph the temples on the upper part of the pyramid (Desmond 1991 and 1994).

The photogrammetric record from these two projects was sufficient for rebuilding should the west façade have collapsed. And while the data is not sufficient for analytical purposes, the US and Mexican archaeologists who carried-out the project gained considerable knowledge of photogrammetric methodology in this first step of a ten year process that led to the comprehensive photogrammetric survey of the Adivino Pyramid in 1999.

### The Adivino Pyramid Conservation Project: 1999

Late in 1997, archaeologists noted additional small cracks (Figure 23) had developed in the walls of the pyramid in spite of the immediate measures taken by INAH archaeologists to stabilize the pyramid and prevented a catastrophic collapse.



Figure 23. Scaffolding for inspection of cracks in stonework, and the interior of pyramid on south side. Pic: Roberto Centeno, 1999.

## Planning documentation

The Adivino Pyramid Conservation Project was initiated early in 1998. Professor of engineering Roberto Centeno L. at the University of Yucatan (UADY) was placed in charge of the project in collaboration with archaeologist Alfredo Barrera R., director of INAH Centro Yucatan, archaeologist José Huchím H., director of the INAH Uxmal Archaeological Project, and UADY's University Center for the Preservation of the Cultural Heritage of Yucatan (CUPPCY), directed by archaeologist James M. Callaghan.

The conservation committee of archaeologists and engineers approved of Desmond's recommendation that the pyramid should first be surveyed using stereo-photogrammetry. Such a survey would allow the measurement of any changes and analysis of the structure. Desmond was asked to coordinate the photogrammetric documentation of the pyramid, and to search for professional photogrammetrists who would be willing to carry out the project on a volunteer basis.

In Mexico, there are highly trained photogrammetrists who work on cartographic projects, but at the time of the project there were none who were trained in the very specialized technique of close-range architectural photogrammetry, so assistance was sought outside of Mexico. In addition, the director requested that the photogrammetrists develop a seminar on the use of photogrammetry for heritage preservation. The field project and seminar were scheduled for March 12 to 24, 1999.

Paul Bryan and Michael Clowes, photogrammetrists with English Heritage's Metric Survey Team, were contacted because of their international reputation as photogrammetrists and surveyors. They were asked if they would be willing to carry out the photogrammetric survey of the pyramid and lead the seminar. They agreed but could only come to Yucatan using their personal vacation time as, at the time, English Heritage had no remit for international assistance.

## Seminar on photogrammetry

Before fieldwork began, Bryan and Clowes led the seminar at the UADY Department of Engineering in Merida. It included photogrammetric theory, a historical overview, and field and laboratory procedures. While a number of archaeologists, conservators, and architects in Yucatan knew of the advantages of using photogrammetry because of Desmond's earlier projects, the seminar provided a more in-depth understanding of its principles and use for recording architecture.

In addition to the presentations by Bryan and Clowes an additional presentation was made by Desmond on the history of photogrammetry for heritage preservation, including previous photogrammetric projects at Chichen Itza, Uxmal, and Labna in Yucatan (Desmond 1991, 1994; Desmond, Collins, Gallareta and Callaghan 2003), and the work of UNESCO's International Committee for Architectural Photogrammetry (CIPA). Callaghan reported on the preservation projects of CUPPCY, and archaeologist Tomás Gallareta N. presented an overview of the archaeology of the Puuc region of Yucatan, and current site conservation projects.

The seminar was continued during fieldwork at Uxmal where instruction was integrated with the actual process of photogrammetric recording of the pyramid. The participants gained first hand experience in the taking of 3-D photographs, the placement of control targets on the pyramid, and in survey methods with a total station.

### Field Equipment

To acquire the necessary imagery, a Rollei 6006 medium (6x6cm) format calibrated photogrammetric camera, with a 50 mm f4 lens was used. At the outset it was recognized this format of image was not ideal for such a large photogrammetry project. The reduced photo scale provided by the Rollei camera did mean that more stereo-photographs had to be taken in order to achieve the desired survey scale of 1:50. However, the difficulties of locating in Mexico the preferred larger format metric camera, such as the Wild P31 or Zeiss UMK 10/1318, meant a medium format camera was the only realistic option for the immediate project. The films used were colour Kodak Professional Ektachrome E100SW, ASA 100 – as the main image base for the survey - and black-and-white Kodak Verichrome Pan (VP), ASA 125 – to act as the archival record.

A Nikon DTM 310 total station theodolite (accurate to 5 seconds of arc in angle and +5mm in distance) was used to acquire the required survey control. A professional land surveyor in Merida, Francisco Mendoza d'Argence, loaned the project the total station and worked closely throughout the entire project with Bryan and Clowes to learn the techniques of setting out and surveying control targets, placement of secondary survey monuments, and the setting of a primary survey grid around the pyramid – all vital components for a successful photogrammetric survey.

### Fieldwork

Targets were affixed on all sides of the pyramid by a team led by archaeologist José Huchím Herrera, using a clear, removable, silicon based adhesive. To increase the archival value of the stereo-photography it was decided to have at least four targets appearing in each stereo pair obtained. The precise arrangement was determined from the ground by Bryan and Clowes, although in reality the 245 targets placed around the pyramid provided an abundance of control.

To enable complete stereo-coverage of the pyramid's exterior, a number of levels of photography were needed. The lower levels were all tackled from the ground, using orthogonal imagery with a restricted upwards inclination of 15 degrees. This would assist both in any later photogrammetric processing as well as providing an easier stereo-pair for off-site 3D viewing and archiving. However to accommodate this restriction the upper levels, including the Chenes Temple 23m up, required the camera to be raised substantially above the ground. For the north, south and east sides, a rented hydraulic lift (Figure 24) mounted on a truck was used to raise the camera, tripod and photographic crew into position. No lift controls were provided in the bucket itself so directions from the crew members to the equipment operator had to be made via radio, in order to place the bucket exactly where needed for each photograph.

As a hydraulic lift could not be physically driven into the plaza that fronts the west façade and no other satisfactory access equipment could be utilized, a scaffold for photography, the full length of the pyramid and 14 metres in height, was built in front of the west façade (Figure 25). This enormous, hand-built scaffold had two main photo platforms from which photography was taken - the first was at approximately 7 metres and the second 14 metres above the ground. But as Le Plongeon had earlier experienced, this upper platform was still insufficient to obtain the ideal, orthogonal stereo pair of the entire Chenes Temple façade. To adequately cover the entire pyramid, a total of 700 3-D stereo-photographs were taken in both black-and-white negative and colour transparency film. As the majority of these were taken orthogonally, together with full control, there was no requirement to augment this with any 'bundle' type oblique photography.



Figure 24. Hydraulic lift with survey camera team photographing the south side of the pyramid. Pic: Roberto Centeno L., 1999.



Figure 25. Scaffolding for photographing the upper part of the west side of the pyramid. Paul Bryan and Michael Clowes are photographing in the upper left corner of the scaffold. Pic: Roberto Centeno L., 1999.

Due to the difficulties of accurately observing polar observations to all 245 targets, using the 'non-reflectorless' Nikon total station, the angle intersection observation method was used. The wide, open space around the base of the pyramid allowed near perfect geometry for such intersected observations. For the west façade this resulted in total RMS orientation accuracies of 0.067m, for the lower strip of photography, 0.062m for the middle and 0.040m for the upper temple doorway. These survey control points were tied into a permanently marked network of 4 major (concrete block) and 6 minor survey monuments, previously located by survey around the base of the pyramid. This would enable all the current survey control and any subsequent sets of survey observations to be tied into the same coordinate system, whilst enhancing the long term ability for data comparison on the monument over time. While on site, the survey data was downloaded daily onto a laptop computer for on-site analysis of accuracy, and blunder detection prior to post processing using the 'Landscape' software package – now part of the Terramodeler survey suite.

### **Post-field work**

After the color transparencies were developed, they were all scanned onto CD using Kodak's PRO Photo-CD™ system. This provided archivable digital versions of all the imagery suitable for any later digital photogrammetric processing using equipment such as Leica's Helava Digital Photogrammetric Workstation (Thomas et al, 1995). For each image this produced working files of approximately 50 Mb in size, with a resolution of around 1200 dpi. All of the original black-and-white negatives, prints and colour transparencies are now stored at the UADY photographic archive in Merida along with a listing of 3-D coordinates for each of the 245 survey control targets and the 10 witnessed, permanent ground monuments.

With this survey, CAD drawings of any part of the pyramid can now be photogrammetrically generated whenever required, using either a digital work station or one of the more traditional analytical stereo-plotters, to supplement the metric data already existing on the monument. As a first step in the current analysis, digital images of the west façade of the Chenes Temple on the pyramid have been processed, using a Helava DPW, to create a measurable orthophotograph (Figure 26). However detailed analysis of just this small section of the pyramid does demonstrate a significant problem within modern orthophotographic rectification using non-orthogonal imagery – note the pixel stretching on the upper levels, caused principally by the use of tilted stereo-photography and receding building detail. Even so engineers and archaeologists within UADY and INAH are currently working with this, and the existing record images and drawings, to analyse the structural stability as well as enhancing the documentation on this impressive monument.

As a result of the successful outcome of this project, in February 2002 R. Centeno of the School of Engineering at UADY purchased a Leica Digital Photogrammetric Workstation. The software modules comprised Socet Set, ORIMA-TB for model triangulation and PRO600 for data capture. The DPW has the full capability of extracting digital elevation models, and the generation of orthophotographs and mosaics. Training



Figure 26. Orthophotograph of the Chenes Temple on the west side of the Adivino Pyramid. Orthophotograph by Michael Clowes, 1999.

and assistance was provided by Clowes during July 2002, this time with the backing of English Heritage following a recent change in the act of parliament that previously restricted work overseas. The primary aim is to set up a laboratory at the School of Engineering for the recording and monitoring of the Adivino pyramid, and subsequently to record other Maya and Colonial buildings in the area. It is also envisaged that some aerial mapping will also be carried out in association with the terrestrial heritage preservation projects. "This will be the first close-range photogrammetric laboratory in Mesoamerica to work directly in support of the conservation of historic and pre-Columbian monuments" (Desmond and Bryan 2001:64).

## Conclusions

The technology for the documentation of architecture has changed significantly over the past 150 years, but the reasons for recording architecture remain much the same. They are to mitigate the impact of the natural environment and human intervention on monuments, and to understand the meaning of an ancient civilization through its architecture. In addition, today the UNESCO *Charter of Venice* mandates



photogrammetric documentation of World Heritage Sites, and conservation planning and structural analysis often require precise survey data of a building.

The detailed illustrations of Uxmal and other sites drawn by Frederick Catherwood in the 1840s, and the beautifully executed large format photographs by Désiré Charnay in the 1860s led to a new approach in documentation by Augustus and Alice Le Plongeon who focused on acquiring a complete and systematic photographic record of a site using medium format stereo images. From the turn of the 19th century to well into the 20th century Maudslay, Graham, Greene and others carried out very comprehensive site surveys at Uxmal, and also throughout Mesoamerica using more compact cameras, and manufactured glass plates and films which could be processed after field work was completed. Finally most recently, architectural conservators and archaeologists in Yucatan in need of an analytical tool to measure structural change and make accurate architectural drawings have adopted the very precise methodology of close-range photogrammetry to record endangered Maya buildings such as the Adivino Pyramid.

In many ways the accurately overlapping stereo images of the Governor's Palace made by the Le Plongeon in the 1870s, using improvised tripods and platforms, anticipate the precisely controlled 3-D photogrammetric images made by the 1999 Adivino Project team from scaffolds and a hydraulic lift. With 3-D images, Augustus Le Plongeon found he could "study the monuments as well, and sometimes better, than if [he] stood before them." And today, while photogrammetry with its digital imaging and other innovations allows us to see the monuments with ever more reality and precision, we can only wonder what our current "cutting edge" technology anticipates.

## References

Baudez, C. F., 1993. *Jean-Frédéric Waldeck, peintre le premier explorateur des ruines mayas*. Editions Hazan, Paris. 199 pages.

Barber, D., 2000. Geomatics for heritage recording: Initial report. Unpublished report: Department of Geomatics, University of Newcastle upon Tyne, Newcastle. 10 pages.

Barrera, R., A. and Huchim, J., 1990. Architectural Restoration at Uxmal, University of Pittsburgh, *Latin American Archaeology Reports*, No.1. 97 pages.

Beale, T. W., 1986. Photogrammetry, computers, and the origins of writing. *Symbols*, September, pages 10-12.

Blom, F., 1932. The negative batter at Uxmal. *Tulane University Department of Middle American Research*, Publication No. 4, Middle American Papers, pages 557-566.

Bourbourg, B. de, 1857-1859. *Historie des nations civilisées du Mexique et de l'Amérique centrale*. 4 vols. A. Bertrand, Paris. V.1: 440, V. 2:661, V.3: 692, V.4:851 pages.

Brewster, D., 1856. *The stereoscope: its history, theory and construction*. John Murray, London. 235 pages.

Brunhouse, R. L., 1974. *In Search of the Maya*. University of New Mexico Press, Albuquerque. 242 pages.

Bush, G., 1975. *Old London. Photographed by Henry Dixon and Alfred & John Bool for the Society for Photographing the Relics of Old London*. Academy Editions, London. 174 pages.

Charnay, D., 1862-63. *Cités et ruines américaines*. Gide, Paris. 543 pages.

Davis, K. F., 1981. *Désiré Charnay: Expeditionary photographer*. University of New Mexico Press, Albuquerque. 212 pages.

Desmond, L. G. and Messenger, P. M., 1988. *A Dream of Maya: Augustus and Alice Le Plongeon in 19th century Yucatan*. University of New Mexico Press, Albuquerque. 147 pages.

Desmond, L. G., 1991. Registro fotogrametrico de la Piramide del Adivino, Uxmal, Yucatan, Mexico: Evaluation de campo, 1990. In Lorena Mirambell, ed., *Consejo de Arqueologia Boletin*, Instituto Nacional de Antropologia e Historia, pages 75-78.

Desmond, L. G., 1994. The use of close-range photogrammetry for archaeological documentation: Chichen Itza and Uxmal 1989. In Virginia M. Fields, ed., *Proceedings of the Seventh Palenque Roundtable Conference*, Vol. IX, San Francisco, Pre-Columbian Art Research Institute, 1994, pages 43-48.

Desmond, L. G., 2001. Augustus Le Plongeon (1826-1908): early Mayanist, archaeologist, and photographer. In David Carrasco, ed., *Oxford Encyclopedia of Mesoamerican Cultures*, 3 vols., New York, Oxford University Press, Vol. 2, pages 117-118.

Desmond, L. G. and Bryan, P. G., 2001. Photogrammetry survey of the Adivino Pyramid at the Maya archaeological site of Uxmal, Yucatan, Mexico. In H. Thwaites and A. Addison, eds., *Proceeding of the Seventh International Conference on Virtual Systems and Multimedia*, pages 57-64.

Desmond, L. G., Collins, P., Gallareta, T., and Callaghan, J. 2003. Gateway into the past: Photogrammetric documentation of the Arch, Labna, Yucatan, Mexico. In L. Barba P., ed., *Antropología y Técnica*, 7 (IIA) 55-66.

Foote, K. E., 1987. Relics of Old London: Photographs of a changing Victorian city. *History of Photography*, 11 (2): April-June, 133-153.

Graham, I. 1992. *Corpus of Maya hieroglyphic inscriptions. Uxmal*. Vol. 4, pt. 2-3. Peabody Museum of Archaeology and Ethnology, Harvard University, Cambridge, Mass. 5 Volumes. Vol. 4, Part 2: 60 pages; Vol. 4, Part 3: 58 pages.

Greene, Merle 1967. *Ancient Maya relief sculpture. Rubbings by Merle Greene*. Museum of Primitive Art, New York. 73 pages.

Greene Robertson, Merle 1995. Merle Greene Robertson's rubbings of Maya sculpture. CD Rom. University of Oklahoma Press.

Kowalski, J. K., 1987. *The House of the Governor: A Maya Palace*. University of Oklahoma Press, Norman. 298 pages.

Le Plongeon, A. Dixon, 1881a. Ruined Uxmal. *The New York World*, June 27:1-2.

Le Plongeon, A. Dixon, 1881b. Ruined Uxmal. *The New York World*, July 18:2.

Le Plongeon, A. Dixon, 1884. An example of patience for photographers. *Photographic Times and American Photographer*, 14(162)(New Series No. 42), June, 302-304.

Le Plongeon, A. Dixon, 1888. Collodion vs gelatine. *Photographic Times and American Photographer*, 18(377):581-582.

Le Plongeon, A. Dixon, 1890. Art photography in London. *Photographic Times*, 20(484): 647- 648.

Le Plongeon, A. 1873. *Manual de fotografia*. Scovill Manufacturing Co., New York. 226 pages.

Le Plongeon, A., 1873. The Morrison lens. *Photographic Times*, 3(33):133-134.

Le Plongeon, A., 1878. Matters of the month. Treatment of albumen paper. *Photographic Times*, 9(94):232.

Le Plongeon, A., 1879. Letter from Dr. Le Plongeon. *Photographic Times*, 9(100):77-79.

Le Plongeon, A., 1882. Dry plates in Yucatan. *Photographic Times and American Photographer*, 12(37):143.

Le Plongeon, A., 1885. Photography not an art. *Photographic Times and American Photographer*, 15(no number) 495.

Le Plongeon, A., 1886. Recovering damaged negatives by means of Eastman sensitive paper. *Photographic Times and American Photographer*, 16(235):157-159.

Le Plongeon, A., 1902. Letter to Charles Bowditch, December 13. Peabody Museum at Harvard University, Cambridge.

Maudslay, A. P., 1974. *Archaeology. Biologia centrali-americana, or, contributions to the knowledge of the fauna and flora of Mexico and Central America* series, edited by F. Du Cane Godman and Osbert Salvin, v.63, *Biologia Centrali-Americana*. R. H. Porter and Dulau & Co., London. Photoreprint of the 1889-1902 ed. published by Milpatron Publishing Corporation for the editors by R. H. Porter and Dulau, London. 6 volumes. Vols. 1-4 Plates. Vol. 5: Text, 204 pages; Vol. 6: Archaeology, 149 pages with an Appendix titled, Archaic Annual Calendar, by J. T. Goodman (unnumbered pages).

Palmquist, P. E, Kailbourn, T. R., 2000. *Pioneer photographers of the far west. A biographical dictionary 1840-1865*. Stanford University Press. 679 pages.

Stephens, J. L., 1843. *Incidents of Travel in Yucatan*. 2 vols. Harper and Brothers, New York. Vol. 1: 329 pages, Vol. 2: 315 pages.

Thomas, P. R., Mills, J. P. and Newton, I., 1995. An investigation into the use of Kodak photo CD for digital photogrammetry. *Photogrammetric Record*, 15(86): 301-314.

UNESCO, 2001. World Heritage Cultural Sites. Uxmal. [UNESCO- World Heritage List](#) [Accessed: 22 August 2015]

Waldeck, J. F., 1838. *Voyage Pittoresque et archéologique dans la Province d'Yucatán pendant les années 1834 et 1836*. B. Dufour et Co., Paris; Chez J. et W. Boone, Bossages Barthes et Lowell, London. 110 pages.

## **Acknowledgements**

The authors would like to thank our colleagues in Yucatan: Archaeologists Alfredo Barrera Rubio and José Huchím Herrera with the National Institute of Anthropology and History, and archaeologist James M. Callaghan and professor of engineering Roberto Centeno Lara with the University of Yucatan, for their brilliant hospitality and technical support during our fieldwork. Great thanks are also extended to the other half of our documentation team from York, England, photogrammetrist Michael Clowes, who carried-out metric survey and photography in Yucatan, and has led the all digital laboratory work, and finally, thanks to San Francisco videographer Kevin Havener for his documentary video on the photogrammetric recording of the pyramid.