The Kuthodaw Pagoda Marble-stelae Inscriptions, Mandalay, Myanmar: Conservation, Photographing, and Study of a Neglected Recension of the Pali Buddhist Canon

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1. The Kuthodaw Pagoda

The Kuthodaw Pagoda in Mandalay in upper Myanmar is commonly referred to as the "World's Biggest Book" (Ludu Daw Ahmar 1980: 5).[2] Consisting of 729 marble stelae[3] spread over a 5.2 hectare site the Pagoda is a large, coherent and historically unique inscriptional complex that preserves an authorised mid-nineteenth century Myanmar recension of the Pali canon, the primary scriptures of Theravāda Buddhism.

Mandalay was founded in pre-colonial upper Myanmar (formerly Burma) in 1857 and the Kuthodaw complex is one of the city's earliest structures. At the centre of this complex is the monument popularly known as the Kuthodaw Pagoda, the "Pagoda of Royal Merit" [Fig. 1]. The 729 stelae are arranged in seven concentric squares around the pagoda. Each of these stelae varies in size—a typical one being 1.3 metres high, a metre wide, with around 75 lines

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[2] The designation "World's Biggest Book" also heads the large notice at the entrance to the site that describes its foundation and content in Burmese and English.

[3] 733 stelae when including the four additional Burmese-language stelae.

inscribed on each side—and is housed in a separate open-sided mini-pagoda around three metres in height (Grönbold 2005: 35) [Figs. 2 & 3].

The version of the Buddhist scriptures on these stelae is the result of a large editing project —a recension—commissioned in the mid-nineteenth century by Myanmar's penultimate king Mindon (reigned 1853-1878) who, to fulfil one of the religious duties of Myanmar kings to preserve Buddhist teachings in a changing world, initiated two ventures regarding the Buddhist scriptures [Fig. 4]. The first began in 1857 when he commissioned the copying of a new set of the canon onto palm leaves (Ludu Daw Ahmar 1980: 15-22). As an outcome of that project the marble stelae at the Kuthodaw were inscribed with a version of the edited text between 1860 and 1868 (Ludu Daw Ahmar 1980: 50-52). Mindon's second initiative was to revive the early Theravāda tradition of holding a council (*saṅgīti*) for the recitation and verification of the words of the Buddha. The "Fifth Buddhist Council" was held in 1871, with 2,400 monks orally reciting the entire canon. Following this, revisions were made to the stelae. The Fifth Council version remained the standard one until the "Sixth Buddhist Council" was held in the mid-twentieth century (1954-1956) in Yangon (however, not all Buddhist traditions accept all of these councils). In 1855, prior to his first initiative, King Mindon had presented a complete set of the scriptures as then constituted (in fine gilded royal manuscripts) to Arthur Phayre, who visited Myanmar as a British representative (Herbert 1989: 64). That set preserves a pre-Kuthodaw version of the text and has lain in the British Library since 1886 only occasionally used.

King Mindon's carving of the entire Pali canon on large marble stelae at the Kuthodaw Pagoda was unprecedented in the Theravāda Buddhist world, and subsequently proved to be highly influential, being the inspiration for the later production of marble stelae editions of the Pali canon, or parts of it, at several sites elsewhere in Myanmar and acting as a model for the carving of non-canonical Buddhist texts at yet other sites in the country (Bollée 1968: 495; Ludu Daw Ahmar 1980: 42-45).[4] The first example of this was undoubtedly the Sandamuni Pagoda site directly adjacent to the Kuthodaw Pagoda which preserves the Pali commentaries and sub-commentaries carved on 1774 marble stelae at the instigation of U Khanti (1868-1949) in 1913.

It is highly likely that Mindon undertook the above projects as part of his attempt to consolidate Buddhism as the state religion and ensure its centrality to the identity of the Myanmar people in the face of the threat of British territorial ambitions in Myanmar—the British had annexed lower Myanmar in 1852, some eight years prior to the beginning of work on the Kuthodaw marble stelae and clearly had territorial ambitions over upper Myanmar as well.

2. Importance of the Kuthodaw Pagoda

The Kuthodaw Pagoda inscriptions preserve a complete and authoritative version of the Pali canon that prevailed in Myanmar until the mid-twentieth century, in the form of a recension originally authorised by monastic scholars in mid-nineteenth century Myanmar; as such they constitute a unique textual witness not influenced by Western textual sources or practices. This

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[4] The carving of the entire Pali canon in Thai script on 1418 marble stelae at the Phutthamonthon Park in Thailand (Nakhon Pathom Province west of Bangkok) in 1957 was clearly inspired by the Kuthodaw Pagoda.

is particularly important given that all subsequent Asian published editions of the Pali canon, including the Sixth Council edition, have been influenced by the European editions published by the Pali Text Society and by Western editorial practices.

The Kuthodaw recension was also highly influential in Myanmar, forming the basis of the "Sixth Buddhist Council" (Chaṭṭhasaṅgīti) text published in Myanmar between 1950 and 1962 (Hamm 1973: 125), which then became the standard edition used in Myanmar. The Sixth Council edition has also come to be one of the most widely used editions internationally today, having been made available electronically in the most easily accessible format and with comprehensive searching tools.[5]

The Kuthodaw Pagoda also represents an important example of both the religious patronage of Myanmar's final royal dynasty and of the response by a Buddhist king to the threat posed by British colonial expansion. It continues to be an iconic and nationally recognised place of devotion for Myanmar's Buddhist majority. Buddhists, both local and international, come to the site for merit making, to meditate, to hear monks preach, and generally to enjoy its sacred and tranquil space [Fig. 5].

The religious status of the site is further witnessed by the many acts of piety that are recorded in the numerous donor inscriptions on the pagodas housing the stelae; these record the gifting of the metal umbrellas that adorn the pagodas, the periodic whitewashing of the pagodas and re-inking of the inscriptions, and the general maintenance of the site [Fig. 6]. As noted above, the Kuthodaw Pagoda subsequently came to act as a model for the production of many similar sites throughout Myanmar and Southeast Asia housing inscribed versions of the Pali canon, the commentarial corpus, or even the contemporary writings in Pali and Burmese of a prominent monk in the case of Ledi Sayadaw at his monastery at Monywa, Sagaing Region.

The status and international significance of the Kuthodaw Pagoda was recognised publically in 2013 with acceptance of the site on UNESCO's "Memory of the World" register [Fig. 7].

3. Prior research

Although there are a number of works containing information about the Kuthodaw Pagoda and the Fifth Council (e.g. Bollée 1968; Braun 2013: 23-28; Ludu Daw Ahmar 1980; မြတ်မြတ် ထွန်း 2007: 81-92; Stadtner 2011: 296-300), not one of these has taken up the question of the contents of the inscriptions and how they differ from other versions. No study has attempted to identify the sources for the readings of the Kuthodaw Pagoda recension, the changes introduced by its redactors, or the influence it had on the subsequent manuscript tradition in Myanmar (Hamm 1973: 126). While Clark (2015a: 99-106) recently investigated its influence upon a section of the important Sixth Council edition, this work needs to be extended to other parts of the canon. The Sixth Council edition is very light on variant readings, with questions about its status being raised by one of the great modern Pali scholars (Norman 2007: xxxvii-xxxviii). Although of great cultural and historical significance, the text recension on these stelae has not been documented or made available to the international scholarly community; it is very much an unknown quantity, a blank on the map of scholarly Theravāda textual

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[5] *Chaṭṭhasaṅgāyana CD-ROM from Dhammagiri, Version 4.0*, Vipassana Research Institute, n.d., Igatpuri. The online version is available at http://www.tipitaka.org/ (accessed 19 June 2016).

explorations, demanding long overdue scholarly attention.

Again, although the Pagoda is of outstanding cultural and religious significance, prior to the current project, there had been no documented systematic attempts at conservation of the site or the inscriptions. To our knowledge, there had been only one attempt at producing a full set of images of the stelae. This was undertaken by Alpha Computer in Mandalay and published as a CD-ROM in 2006 (မဟာဂန္ဓာရုံကျောင်းတိုက်, သီတဂူကမ္ဘာ့ဗုဒ္ဓတက္ကသိုလ် and Alpha Computer). Unfortunately, this resulted in low resolution images that are mostly unreadable. Prior to this, Willem Bollée of the University of Heidelberg, Germany, had photographed a portion of the inscriptions in January or February 1965. According to Bollée (1968: 496) he "photographed the Sutta and Abhidhamma pitakas only, because the Vinaya slabs were reproduced in a folio volume published in 1928, a book difficult to procure even in Burma at present." Bollée subsequently donated the film rolls to the Institute of Indology at the University of Hamburg. Here also the quality of these images appears rather poor, based at least on scans of several of the original black and white photos supplied to us by the University of Hamburg.[6] Consequently, to date, very few scholars have been able to see the inscriptions, much less research them or compare their contents with earlier or later versions. Similarly, there had been no attempt to verify historical information concerning the site and the inscriptions. For example, Ludu Daw Ahmar (1980: 23) reports that the inscribed text on the stelae had originally been highlighted in gold paint but that this was removed by British forces after seizing Mandalay in 1885 and subsequently replaced by black ink in recent times. However, close inspection of the stelae by members of the current project, including the project's conservator, failed to identify any remnant of gold in the inscribed text. It was also apparent that it would have been extremely time consuming and labour intensive to have undertaken such a task, with the quantity of gold that would have resulted making the exercise uneconomical. In light of this, it is therefore likely that the account is apocryphal.

The exception to the above paucity of research on the Kuthodaw Pagoda and on the status of the Kuthodaw recension is the work of the late Primoz Pecenko, a Pali scholar who was based at the University of Queensland, Australia, and who initiated a research project on the Kuthodaw Pagoda in approximately 2004. Unfortunately, Pecenko's unexpected passing away in 2007[7] brought the project to an end in its early stages, with his preliminary comparison of the Fifth and Sixth Council versions of the Dhammapada or sections of it, for example, remaining unpublished.

4. The establishment of the Kuthodaw Pagoda Project

In 2013, inspired by Pecenko's research, a group of scholars and students at the University of Sydney and Nan Tien Institute, Wollongong, established the Kuthodaw Pagoda Project with the aim of photographing, documenting and studying the Kuthodaw Pagoda site and its inscriptions. However, as will be discussed in greater detail below, an initial assessment of the site the same year by Mark Allon and Chris Clark revealed that the text on many of the stelae

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[6] We would like to thank Prof. Bollée for supplying information about his photographing of the inscriptions and Birte Plutat of the Bibliothek des Asien-Afrika-Instituts, University of Hamburg, for suppling us with scans of the images.

[7] See Allon 2009.

had become obscured by decades of dirt, whitewash, graffiti, insect nests, and animal droppings, while the most recent re-inkings of the text had frequently become thin and worn, or had been done inaccurately or clumsily, making the text illegible even through high resolution photography. It was therefore realised that the stelae would need to be cleaned and conserved before photography could begin, while further degradation of the inscriptions could only be prevented by securing the metal-grille doors that protect the pagodas through the provision of locks, by undertaking repairs where necessary, and through initiating a conservation plan for the site. This assessment of the site also revealed that the inscriptions and their pagoda housings were threatened by advancing vegetation (overhanging trees and weeds) and accumulated rubbish.

In 2014, in order to undertake this conservation work, the photographing of the inscriptions, and the transcription project, we applied for and won a three year grant from Chuo Academic Research Institute (CARI) of Rissho Kosei-kai, Japan (2014-2016). The grant covers the following work:[8]

- To clean the inscriptions and to produce a long term strategy for their restoration and conservation.
- To digitally photograph all the inscriptions carved on the marble stelae.
- To produce and make freely available a database of the high resolution images of all the inscriptions.
- To create an electronic edition of the Kuthodaw Pagoda text.

The Kuthodaw Pagoda Project team currently consists of textual and language scholars, conservators, archaeologists, and IT specialists from the University of Sydney and Nan Tien Institute, Wollongong (both in Australia), and conservators from the Department of Archaeology, Mandalay, Myanmar. The team is also working closely with Mandalay-based photographers and monks from the Sitagu International Academy, Mandalay. The project has also benefited greatly from the input of Alexey Kirichenko of the Institute of Asian and African Studies at Moscow State University whose knowledge of Myanmar manuscripts and inscriptions and monastic history, as well as local institutions has proved invaluable.

Australian team members are

- Mark Allon (Chair, Department of Indian Subcontinental Studies, University of Sydney).
- Tamara Ditrich (Head of Program, Buddhist Studies at Nan Tien Institute, Wollongong, and Adjunct lecturer at the University of Sydney).
- Wendy Reade (Lecturer in Ancient Near Eastern Art and Archaeology and consultant conservator, University of Sydney).
- Bob Hudson (Honorary Associate and consultant archaeologist, Department of Archaeology, University of Sydney).
- Royce Wiles (Lecturer, Nan Tien Institute).
- Chris Clark (Honorary Associate, University of Sydney).
- Ian McCrabb (project consultant; PhD student, University of Sydney).

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[8] For an initial notice of CARI funded project and subsequent progress report, see Allon 2014 and Allon 2015.

Myanmar team members include
- Department of Archaeology Mandalay: U Nyo Myint Tun, Director,[9] U Naing Win, Assistant Director, and conservators and general staff members. The local project manager is U Wai Lwin, a retired Department of Archaeology staff member.
- Kuthodaw Pagoda Trustee Committee.
- Photographer: U Kyaw Thu Win and team of Hla Gon Yee (Photo and videos), Mandalay.
- Sitagu Sayadaw Ashin Ñāṇissara, Chancellor of Sitagu International Academies, Sagaing and Mandalay and monks from the Sitagu International Academy, Mandalay.

Permission to undertake the cleaning, conservation, and photographing of the Kuthodaw Pagoda stelae was kindly granted by U Aye Myint Kyu, Minister of Culture, Myanmar Ministry of Culture, Myanmar (February 2015). The team also worked closely with U Kyaw Oo Lwin, the Director-General of the Department of Archaeology, National Museum and Library, Ministry of Culture, Myanmar.

5. Conservation assessment of the site and stelae, solutions, and work undertaken to date

A preliminary assessment of the Kuthodaw Pagoda site and inscriptions was undertaken by Allon and Clark in July 2013. On the basis of CARI funding and the official establishment of the Kuthodaw Pagoda Project, a full assessment of the site and inscriptions was made by team members, including the conservator Reade, in November 2014. During this period, Department of Archaeology Mandalay conservators and staff members were trained by Reade in the best methods for cleaning the stelae. At this time the site and the project's work were inspected by Daw Sanda Khin, Deputy Minister of the Myanmar Ministry of Culture.

Apart from actions of donors over the years to whitewash the pagodas and re-ink some inscriptions, for example, there is no known record of conservation assessment or treatment of any part of the site, nor has there been a maintenance plan to date. Despite being listed on the UNESCO Memory of the World register, and being a tourist destination and a functioning Buddhist complex, the site had suffered neglect overall. Before the photographic component of the current project could be undertaken, a conservation assessment and treatment of preservation issues, particularly relating to the stelae, had to be addressed.

In addition to the general description of the site already given, it is useful here, for the purpose of understanding the conservation issues, to provide further detail of the site and the fabric of its construction. Between the seven concentric squares of pagodas are two avenues planted with large starflower trees (*Mimusops elengi*), many of which have now overgrown pagodas. The site is paved partly with concrete and partly with paving stones, although the ground around the pagodas of the outermost rows is largely unpaved, allowing extensive growth of weeds, vines and sapling trees. The pagodas are small square cement-rendered brick buildings with tiled floors raised approximately half a metre above the outside ground level and with large openings or doorways on the four sides. Each pagoda is whitewashed inside and out. Although the doorways were originally open, steel grilles were added at a later period, the front opening fitted with a lockable door that allowed access to the interior, thereby forming the

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[9] Prior to his retirement, the team also worked closely with the previous Director, U Zaw Oo Han.

entrance to the pagoda.

Each pagoda contains a stela cut from local grey-white streaked marble. The stelae are set into the tiled pagoda floors and are cemented in place. The incised inscriptions on both sides of the stelae are painted black. While the traditional ink recipe is said to have been formulated by mixing shellac with carbon black, solvent testing and observation of the practice of contemporary craftsmen working around the Mahamuni Temple, in Mandalay, suggest that the black paint could be Unilac enamel paint made by UPG (United Paint Group), a local Myanmar company. Where necessary, the inscriptions are occasionally carved around natural faults in the stone, and there is evidence that corrections on some of the inscriptions have been made by cutting back the stone and re-engraving the text, or more commonly by repainting and also correcting in paint where the engraving is in error. The top and sides of the stelae are painted in multiple layers of red that are now thick and sometimes lifting.

There is a range of non-intrusive additions on many stelae. These include dedicatory graffiti written on the marble in black ink at the top centre of most of the stelae surveyed. A square of gold leaf has been applied at or near the top centre of some stelae. Lines have been drawn down one side of some of the marble stelae previously to aid in study of the texts. These features do not interfere with the inscriptions and form part of the history of the stelae.

Both faces of each stela have been coated with a protective material that has a translucent brownish colour, which darkens the appearance of the stone. The coating stops just below the inscriptions, almost invariably fringed beneath with run marks where the coating has flowed down to the floor, indicating that it was applied as a liquid [Fig. 8]. Raman spectroscopy analysis of samples of the coating taken from two stelae is currently being conducted with preliminary results indicating that the coating material is likely to be an acrylic emulsion.[10]

Conservation assessment 2014

The preliminary conservation condition survey was carried out over approximately five days in November 2014. Reade, Allon and Clark walked the site to gain an overall impression of the condition and conservation issues, and to identify the most problematic stelae for immediate assessment. Different sections of the site were then targeted for condition assessment in order to obtain a representative cross-section, particularly of pagodas and stelae, across the site. Nearly 35% of pagodas and stelae were assessed. The main threats to preservation were identified as:

- Moisture.
- Vegetation.
- Human impact.
- Lack of regular maintenance and documentation.
- The presence of bats.

A major problem at the Kuthodaw Pagoda site was that approximately half of the metal-grille doors to the pagodas that housed the stone inscriptions were damaged or unlocked, which allowed visitors to enter the pagodas. This resulted in graffiti being written on the stelae and internal pagoda walls, rubbish being deposited, and in some cases people living in the pagodas.

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[10] Analysis is being conducted by Elizabeth Carter, Vibrational Spectroscopy Core Facility, University of Sydney, in consultation with Paula Dredge, Art Gallery of New South Wales, Australia.

It was therefore imperative that pagodas be locked. These and other recommendations were detailed in the full conservation condition assessment submitted to the Myanmar Ministry of Culture late in 2014. This report included treatment proposals based on the results of testing, and future maintenance guidelines.

Moisture and vegetation

Many pagodas have rising damp that causes the whitewash to flake off the walls and, in the worst cases, the rendering to fall away exposing the brick structure. This has occurred in only a few pagodas. The rising damp also encourages the growth of black mould and green moss on the lower parts of the inside walls in many pagodas. Tree branches overhung the pagodas, exacerbating the moisture problem, which in combination with the warm and humid climate of Mandalay, resulted in the growth of black mould on the exterior of pagodas. The marble stelae appear to be unaffected by damp, due in part to being raised above the ground level.

Occasionally plants were found growing up between the floor tiles and the walls of pagodas, and on the roofs of pagodas where their roots are causing the brickwork to crumble. Overgrowth, especially around the outer squares of pagodas also includes the growth of vines up the steel grilles, and impeded access to sections of the site. Drainage across the site was hampered because drains were often blocked with rubbish, soil, plants and other debris [Figs. 9 & 10].

Human impact

Approximately half of the pagodas were unlocked allowing access by visitors who gather for picnics and leave their rubbish behind, including food scraps, broken glass and sometimes faeces inside and outside the pagodas. Some pagodas were used for storage and for sleeping. Many stelae had graffiti written on them predominantly with opaque correction fluid, also known as "liquid paper," but occasionally also in pencil or other media, and inside pagoda walls had graffiti written on them, including over dedicatory plaques, as a result of unmonitored visitor access.

Each pagoda is whitewashed inside and out, a task periodically repeated without protecting the stelae. This had resulted in considerable whitewash splashing onto the stelae and floors of most of the pagodas. The extent of splashing varied from just a few spots, to extensive splattering on some of the stelae, including what appear to be instances of whitewash brushes being wiped clean on the stela [Fig. 11].

When the pagoda floors were swept, the litter was not removed but was piled up against the window grilles. The stelae were dusty, some more than others, to the extent that the upper sections of the inscriptions were sometimes obscured by dust, accreted dirt, small spider webs and mud wasp nests.

Some of the metal-grille pagoda doors had been bent so that they no longer closed easily. The anchor points for the door hinges and door locks had been cemented into the pagoda doorways. Some of these anchor points had pulled out, were loose or cracked and were therefore less secure [Fig. 12].

Building debris and rubbish were piled up around the site.

Bats

Bats roost in some of the pagodas, apparently hanging from the recess set into each of the ceilings. The presence of bats in the pagodas is indicated by the accumulation of bat droppings

on top of the stelae and on the pagoda floors. In some pagodas, this is the only indication that bats are roosting. In more severe cases, bat urine has discoloured the face of the marble stelae, creating long and broad brown stains that are white at the centre where the marble surface has been degraded by the acidic urine. These stains obscure the inscriptions, particularly under the white regions [Fig. 13].

Of the 249 stelae surveyed, 21 (8.4%) were found to have comparatively extensive bat urine stains, while a further 36 stelae (14.5%) had minimal bat urine stains, consisting mostly of small white runs that have not yet altered the face of the stone. This means that a total of 23% of the stelae surveyed have been marked by bat urine. It is noted that this initial survey of the site specifically selected badly affected stelae to be included in the condition survey, meaning that these percentages are weighted more significantly than the survey of one third of the site might suggest.

Conservation test cleaning of stelae 2014

In addition to the condition assessments carried out in 2014, treatments were tested for a variety of problems identified on the marble stelae. The aim, in line with accepted conservation practice, was to identify the most appropriate, minimal and non-invasive treatment strategies. A methodology had to be designed that was practical on a large site using local workers who had to be trained, and with limited resources, employing locally sourced materials as far as possible.

During treatment testing, the surface of the stone was inspected with a magnifying lens periodically to make sure that no visible damage was being caused to the stone or painted inscriptions. Test treatments included:

- simple washing of the marble surfaces with a variety of damp cloths, some more abrasive than others
- washing with water solutions containing additives such as ammonia, neutral pH detergent and ethanol
- mechanical removal of dirt and other material with brushes, wooden picks, abrasives, such as bicarbonate of soda, and poultices
- removal of graffiti with acetone on cotton swabs.

The protective coating on the stelae facilitated the removal of dirt with water-dampened cloths. No other additives were required. It also facilitated the removal of other materials from the surface of the stone, and had prevented the whitewash and liquid paper from penetrating the stone and depositing residue that would have been difficult to remove. The coating was found to be soluble in acetone, which resulted in its unavoidable removal where liquid paper graffiti was removed with this solvent. No other combination of available solvents would remove the graffiti without removing the coating.

Removal of whitewash from the incisions of the inscription proved more difficult. Various abrasive and solvent methods were tested, and while the black paint remained unaffected, progress was labour intensive. The whitewash was effectively softened by the application of water on a cotton swab held in place for a few seconds, and could then be removed with wooden picks.

The effect of bat urine is cause for concern, as the acidic urine can chemically damage the marble, despite the protective coating, although this has undoubtedly slowed the degradation that results from prolonged contact of the stone with the urine. Bat urine contains high

concentrations of uric acid, which can etch polished surfaces and stain porous stone such as marble. Various cleaning methods were tested, but it was found that simply washing with water and drying the stone with a cloth afterwards removed the brown stains. The pH of the stone surface was tested in July 2015, some six months after cleaning, and each test returned a neutral pH result, indicating that there was no residual acid.

A test patch of the damaged stone was polished with 0000 steel wool, which with effort removes some of the crusty white layer revealing less damaged stone. This in turn has the effect of making the inscription clearer, but the white crystallisation in the incised writing is too hard to remove by polishing out. While polishing with 0000 steel wool lessens the obscuring visual effect of the whitened regions, it is extremely time consuming, and was not pursued.

The problem of the bats is a continuing one. As the pagodas cannot be completely sealed, there is no way to prevent the bats from entering them. It is a larger issue beyond the scope of this project and requires expert, local knowledge.

Many stelae had cement spattered across their surfaces from careless work on the pagodas, including from floor tiling when excess cement has been wiped over the bottom of some inscriptions. The cement is easily removed by the careful use of small hand tools, where abrasives, solvents, and poultices were ineffective and time consuming. The relative ease of mechanical removal is due to the presence of the coating layer and the polished surface of the stone.

Cleaning and maintenance in 2015

In early 2015 the Kuthodaw Pagoda Project purchased locks for the doors of the 731 pagodas[11] and the Department of Archaeology repaired the doors and fitted the locks. All pagodas are now locked, with the exception of a select few near the entrance to the site left open to allow visitors to inspect the inscriptions.

In January to February 2015, following the Ministry of Culture's approval of the conservation report recommendations, an initial cleaning of the stelae and site maintenance was undertaken by the Department of Archaeology Mandalay, headed by Daw Aye Aye Khine. This work included:

- Clearing away rubbish from inside the pagodas.
- Cutting back some of the overhanging trees, removing plants growing on the pagodas, cleaning away some of the rubbish and weeds from the surrounding area, and spraying with weed killer.
- Repainting pagoda numbers that had been covered over with whitewash.
- Following the conservation practices established by Reade, the Department of Archaeology team cleaned the stelae and removed the whitewash using water and small scrubbing brushes, and removed the graffiti using acetone with cottonwool buds.
- Taking conservation quality photographs of the stelae post-cleaning, and continuing the documentation of work that was started in November 2014.

In July 2015 Allon and Reade, along with trainee-conservator Grace Flitter (Plymouth University), worked closely with conservators and staff of the Mandalay Department of Archaeology and the Kuthodaw Pagoda Trustee Committee on the following [Figs. 14 & 15]:

- Training of seven Department of Archaeology staff, a manager and two labourers in the

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[11] Three of the Burmese-language inscriptions are housed under one pagoda.

best methods for undertaking the final cleaning of the stelae, which progressed well as the trainees formed teams that worked progressively from pagoda to pagoda.

- Lopping of trees that still overhung the pagodas, removal of plants growing on pagodas, and the clearing away of rubble, rubbish, and weeds from around the site, undertaken by the labourers.
- Preparation of guidelines for the Department of Archaeology team for the cleaning of the stelae.
- Preparation of guidelines for the future maintenance of the site, including procedures for whitewashing of the pagodas and re-inking of the inscriptions, to prevent further damage. Site maintenance of drains, vegetation and visitor access to pagodas was included.
- Collection of samples of the existing preservative coating for analysis and identification. The results of this analysis will influence the decision of whether to recoat the stelae and with what material. The current acrylic emulsion coating is most likely locally available, has caused no damage to the stone, and can be applied relatively quickly by brush, and removed easily with acetone. Its disadvantage is its brownish colouration.
- Testing the application of conservation quality colourless microcrystalline wax as a possible coating material to protect the stone inscriptions. It would replace or supplement the previous coating, but is not locally available and likely much more costly than the local acrylic emulsion alternative. To completely remove the old coating and to recoat the stelae presents issues of time, cost of materials and labour, and sourcing of the coating wax. At the time of writing, these issues are being considered before a final decision is made about this last stage of treatment.

The primary concern of the conservation programme is to protect the stones and their inscriptions from further damage, and to ensure that the site is well maintained for its future preservation. To this end, it has been a pleasure to work together with the Kuthodaw Pagoda Trustee Committee of the site, the Department of Archaeology in Mandalay and the Myanmar Ministry of Culture in a most successful and productive collaboration.

6. Imaging techniques tested

In 2014 team members tested a variety of imaging techniques either in Australia or at the Kuthodaw Pagoda, or in some cases at both locations. Some techniques were investigated, but not tested. The factors that were taken into consideration in assessing each technique were (1) the quality and nature of the resulting images (the latter with a view to ease of mounting in a database and user accessibility); (2) the time, labour and cost involved in the production of the images, both onsite and post-production; (3) and the constraints imposed by local conditions on site, such as the restrictive space between the pagoda housing and the stela, access to electricity, and climate. The imaging techniques tested were

- 3D scanning.
- Reflectance Transformation Imaging (RTI) / Polynomial Texture Mapping (PTM).
- Photogrammetry.
- Litro Illum camera.
- Digital SLR photography.

3D scanning

The Artec Spider 3D scanner was tested on select stelae at the Kuthodaw Pagoda in November 2014 [Fig. 16] and on comparable sandstone gravestones at cemeteries in Sydney, Australia, around the same time.[12] The Artec Spider is a hand-held device approximately the size of a large iron that is moved slowly over the inscription following a grid pattern. The data is transmitted directly to a laptop onsite which allows real-time assessment of the image. These images then require post-processing. The output is a 3D colour image that can be manipulated spatially through appropriate software (e.g. Meshlab). Although the images that resulted from these tests are good, they are not as sharp and legible as the digital SLR photos taken at the same time (see below). This might have been due to the shallowness of the engraved text, or possibly a limitation of the Artec Spider, the technique used during this trial, the software, the laptop, or some combination of these. Apart from image quality, a significant limitation of the technology is the time taken to scan a stela (or gravestone) and the even greater time required for post-processing. Other limiting factors are the power requirements of the scanner and accompanying laptop and the processing power of the laptop—the more powerful the laptop, the faster the onsite processing.[13] Finally, the large file size of 3D images may inhibit their being mounted on a platform accessible to the public. However, despite these limitations, advances in this technology may prove it to be highly suitable for imaging inscriptions in the near future.

Reflectance Transformation Imaging (RTI) / Polynomial Texture Mapping (PTM)

Reflectance Transformation Imaging (RTI) or Polynomial Texture Mapping (PTM) "is a computational photographic method that captures a subject's surface shape and color and enables the interactive re-lighting of the subject from any direction.... RTI images are created from information derived from multiple digital photographs of a subject shot from a stationary camera position. In each photograph, light is projected from a different known, or knowable, direction. This process produces a series of images of the same subject with varying highlights and shadows. Lighting information from the images is mathematically synthesized to generate a mathematical model of the surface, enabling a user to re-light the RTI image interactively and examine its surface on a screen."[14]

The first use of RTI for Southeast Asian inscriptions appears to have been by Arlo Griffiths (EFEO) who, along with Bob Hudson (a member of the Kuthodaw Pagoda Project), tested the technique on Pyu, Sanskrit, and Pali inscriptions in Myanmar in April 2014.[15] Although the resulting RTI images provide a powerful means of reading the inscriptions imaged, the technique proved inappropriate for the Kuthodaw inscriptions due to the limited space between the stelae and the pagoda housing and the restrictions imposed by the metal grilles and door

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[12] The Yangon-based company Life and Challenge was employed for the trials at the Kuthodaw Pagoda, while the Sydney-based company Qubic (Crows Nest, NSW) demonstrated the Artec Spider in Australia.

[13] Electricity is not easily accessible at the Kuthodaw Pagoda and laptop batteries typically only last a few hours. The technology no doubt works best in an indoor environment where electricity is at hand and the scanner can be connected to a powerful desktop computer.

[14] Cultural Heritage Imaging: http://culturalheritageimaging.org/Technologies/RTI/.

[15] We would like to thank Dr Griffiths, who trained in RTI at the University of Southern California, for the information he supplied on RTI and his experience with Southeast Asian inscriptions.

that guard the four openings in the pagodas.[16] It is also possible that the technology may lack long-term support given that Hewlett-Packard, the creator of the software required to process and manipulate the images, has not further developed its RTI software in recent years.

Photogrammetry

Photogrammetry involves taking multiple images of an object from different locations with standard digital equipment that are then processed by software to produce an "extremely dense and precise 3D surface data".[17] Multiple images of a select Kuthodaw stela taken by Allon in November 2014 were processed by Paul Bourke, then of the University of Western Australia.[18] The resulting image was similar in quality to the 3D scanning discussed above, and like 3D scanning the time involved in taking the multiple images and in post-production ruled against this technique being used.

Litro Illum camera

The Litro Illum camera harnesses the entire light field to retain the richness and depth of a scene and enables one to "explore focus, perspective, and depth of field within a single image and render full-color, 3-D living pictures."[19]

The camera was trialled on sandstone gravestones in Sydney in October 2014 by Kate Andrews of Systemik Solutions Pty Ltd. However, the lack of depth in the inscriptions on the gravestones, which is comparable to that on the Kuthodaw stelae, meant that the dynamic qualities of the technology were not fully realized. The camera was therefore considered inappropriate for photographing the Kuthodaw inscriptions.

Digital SLR photography

Digital SLR photography was tested on the Kuthodaw stelae in November 2014 by team members and by Alexey Kirichenko, photographing under different conditions using a variety of cameras and lenses. Kirichenko, who has extensive experience photographing Burmese manuscripts and inscriptions, demonstrated photographing the inscriptions at night. The team also commissioned local professional photographer U Kyaw Win and his company Hla Gon Yee, Mandalay, to take a series of photographs during the day.

Photographing at night, with lighting provided by fixed LED lights, results in an even distribution of light across the surface of the stela and in the shadows cast in the engraved letters. A further advantage of photographing at night is that the entire corpus of inscriptions is photographed under the same light conditions thereby creating a homogeneity in the quality of images across the corpus. In contrast, in daylight photography the quality of the images is influenced by natural variations in the lighting—time of day, weather, and season.

However, although the photographs taken by Kirichenko at night were of a very high

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[16] The changing (or multiple) light position must be at least three times the diagonal length of the object recorded (James Miles, personal communication).

[17] http://culturalheritageimaging.org/Technologies/Photogrammetry/.

[18] We would like to thank Dr Paul Burke for the assistance he generously gave us in trailing this technique.We would also like to thank Dr James Miles, Archaeological Computing Research Group, Department of Archaeology, University of Southampton, UK, for information he provided on photogrammetry and RTI. For a comparison of the two techniques, see Miles et al. 2014.

[19] https://store.lytro.com/products/lytro-illum.

quality, photographing at night was deemed impracticable for this project given that permission to work at night at the site would be difficult to obtain, shooting at night would also require additional paid staff to facilitate access out of hours, and a professional local photographer would be less likely to want to work at night. It was also the case that the photographs taken by local professional photographer U Kyaw Win during the day were of a similar high quality to those taken at night, though there is greater diversity in lighting and colour. In other words, in terms of legibility of the text, both techniques produced similar results. The project therefore employed U Kyaw Win to photograph the stelae during the daytime.

The photographing of the Kuthodaw Pagoda stelae

The photographing of the stelae by U Kyaw Win started in July 2015, beginning with stela no. 1 and progressing sequentially through the site following the Department of Archaeology team which was undertaking the final cleaning of the stelae. Six photographs were taken per stela: a full face and two half faces (top and bottom) of each side. The camera used was a Canon EOS 5D Mark III and the output is raw CR2 and jpeg files. Prior to shooting, the stela was dampened with a wet cloth and patted dry, which darkens and highlights the black ink of the inscribed text and generally brightens the colours. The main problems were drying the stone before the photograph was taken (because of the hot climate), which results in sporadic less legible dry patches, or over-wetting, which results in the text being obscured by reflection in the resulting photograph. The quality of the images is impressive. In most cases the text is legible in the full face image; the half-face images will be for closer reading of the text. The photographing of the 729 stelae containing the canonical texts and the additional four Burmese-language stelae containing historical information was completed in June 2016.

7. Preliminary study of the status of the recension

By the time the Kuthodaw Pagoda stelae were inscribed, Pali literature had been transmitted in Myanmar for centuries through successions of handwritten manuscripts. Evidence suggests that the Kuthodaw Pagoda recension of the Pali canon exerted a strong influence upon the subsequent manuscript transmission in Myanmar (Clark 2015b: 87). It is also one of the main sources for the widely used Sixth Council edition (Clark 2015a: 99-106). Therefore, a comprehensive understanding of the status of the Kuthodaw Pagoda recension within the broader transmission of Pali literature in Myanmar is a major desideratum.

A preliminary investigation into this topic was undertaken by Clark (2015b) during his doctoral research on a Pali canonical text called the Apadāna. The version of this text found on Kuthodaw Pagoda stelae 665-687 was compared alongside nineteen different manuscript versions. When closely compared to Burmese script manuscripts predating the 1860s, it became evident that the Kuthodaw Pagoda recension represents a rigorously edited and newly revised version with a number of key features. Firstly, it contains far fewer errors than most Burmese script manuscripts, though more than most modern printed editions. Secondly, hypermetric *pāda*s within *śloka* verses have been avoided in favour of metrically standard eight syllable *pāda*s. This usually involves an alteration of *sandhi*[20] or word choice.[21] Nonetheless,

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[20] For example, *catunavut' ito kappe* instead of *catunavute ito kappe* (Ap 55,19).

[21] For example, *purāṇapuḷinaṃ hitvā* instead of *purāṇaṃ puḷinaṃ chaḍḍetvā* (Ap 79,3).

this recension does sometimes contain hypermetric *pāda*s.　Thirdly, grammar or word choice has occasionally been altered in order to make difficult passages more easily understood.[22] Fourthly, the text has been harmonised with parallels in other parts of the canon in order to improve textual consistency.[23]　The downside of this is that it hides the natural diversity found within the historical transmission of Pali literature.　Lastly, there is evidence of occasional conflation, that is, the combination of two or more variant readings.[24]　The extent to which these preliminary observations apply to the rest of the Pali canon remains to be investigated.

8.　Future work

　　Two of the four aims belonging to CARI funded project have been achieved to date, namely, (1) cleaning the stelae in preparation for photographing the inscriptions and securing the long-term protection of the inscriptions by ensuring that the grille doors are locked, that weeds, rubbish, and overhanging trees have been removed, and that a conservation strategy for the inscriptions and site is in place; and (2) producing a set of high quality digital images of the inscriptions that can be mounted on an open access platform and can act as the basis for producing a transcription of the text of the Kuthodaw Pagoda stelae.

　　The remaining two aims of CARI funded project are (3) to produce and make freely available that archive of images and (4) to create an electronic edition of the Kuthodaw Pagoda text.

　　Regarding the third aim, which will be completed by the end of 2016, the construction of an open access image database with metadata is becoming the norm for Buddhist studies, particularly manuscript studies, as it is for fields concerned with the study of historical documents and monuments in Asia.　However, this technology has not yet been applied to Buddhist textual and historical materials and monuments of Myanmar.

　　It is anticipated that a citable web-based platform (e.g. Open Context) for the publication of research data will be utilised to host the images and associated metadata.　The key advantage of this approach is the potential to leverage a stable supported open source platform purpose built for this type of data set.　By aligning with “Linked Open Data” standards, the Kuthodaw Pagoda images will be exposed in a manner which will facilitate free and open access for researchers via browse and search.　The exposure of application programmatic interfaces (APIs) to backend services will support programmatic integration of the data set with related systems, opening up possibilities for a wide range of research opportunities.

　　It is also anticipated that the platform will eventually host related materials produced by the project, such as images or scans of the donative inscriptions associated with the stelae, important manuscripts and printed editions, and other historical documents and photos concerning the creation of the site.　The project thereby aims to make available previously

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[22] For example, *tiyojanāni sāmantā* instead of *tīṇiyojanasamantā* (Ap 73,32).　As stated by Clark (2015b: 201), “While the cardinal three is most often *ti-* at the beginning of a compound, it may also be *tayo-* and *tīṇi-*”.

[23] For example, Ap 59,1 (*ath' ettha satthā āgañchi*) has been harmonised with the reading found at Th 559 (*bhagavā tattha āgacchi*).

[24] Most notably, the Kuthodaw Pagoda recension of Ap 70–72 (verses 1–26) appears to have resulted from an editorial attempt to include the readings from two different versions of this passage.　It consequently has four additional verses not found in the received text.

untouched primary materials to scholars of other disciplines, most notably historians, as sources in their on-going attempts to explicate and narrate the history of the entire region, besides making them more readily available to the people of Myanmar.

The creation of an electronic edition of the Kuthodaw Pagoda text (aim 4) is currently underway. The project is fortunate to have gained the assistance of Sitagu Sayadaw Ashin Ñāṇissara, Chancellor of Sitagu International Academies, Sagaing and Mandalay, Myanmar, for this task. A small team of monks from the Sitagu International Academy, Mandalay, will work in pairs, each changing the reading of the electronic Roman version of the Sixth Council text to that of the Kuthodaw recension utilizing the images produced by the project.[25] The two resulting files will be compared and the differences highlighted, a process that is easily automated. A third person will check the resulting points of difference against the original images and select the correct reading. Although this method will not capture all errors—for example, both monks transcribing the same text may make the same mistake—it will produce the most accurate reading with the resources available. Producing a transcription of the entire Kuthodaw recension of the Pali canon by this method will undoubtedly continue into 2017. However, the project aims to have the transcription of select texts available for mounting on its web-based platform by early in 2017.

The establishment of a digital platform with the capability to support the linking of the images and the complete Roman-script transliteration of the Burmese-script Kuthodaw Pagoda inscriptions and to simultaneously read and compare this recension of the Pali canon with the Sixth Council edition and with other witnesses from the wider textual tradition of Myanmar, is a longer-term goal of the project that requires further funding.

Towards this end, the project will, with the aid of funding from the Sydney Southeast Asia Centre of the University of Sydney, pilot the importing (on boarding) of the images and transcriptions of a select number of texts into Research Environment for Ancient Documents (READ), a philological workbench and publishing platform developed, in consortium, by the University of Sydney.

By utilising READ, we will take advantage of a digital paradigm shift from strings of marked-up text (Text Encoding Initiative model) to sequences of semantically linked entities. This approach enables integration of the image and multiple transcription editions. Entity level annotation, attribution, ownership and visibility support granular analysis, collaboration and comparison of alternative editions. In READ palaeographic, phonological, grammatical, orthographical and morphological analysis outputs are automated and new research methods in network and pattern analysis are enabled.

The pilot project will involve configuration of the READ system ontology and parser to support import of the edited Roman script pilot texts. Once imported, these texts will undergo detailed annotation with grammatical tagging, glossing and sequencing of textual divisions. The transcription will also be linked to the corresponding digital images syllable-by-syllable.

The outcomes produced with the assistance of CARI funding, particularly the landmark production of high quality digital images of the Kuthodaw inscriptions and transcriptions of

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[25] For a variety of reasons we have utilized the Digital Pali Reader's version of the Sixth Council edition, which is a modification of the Sixth Council text produced by the Vipassana Research Institute (http://www.tipitaka. org/), which in turn made small editorial changes to the text of the printed edition. This supposed Sixth Council text will eventually need to be compared with the printed edition.

selected texts, are the foundation for several further important aims of Kuthodaw Pagoda Project.

The first aim is to determine the nature, status and influence of the recension preserved in the Kuthodaw site. For this, the Kuthodaw recension will be compared with earlier and later versions of select canonical Pali texts transmitted in Myanmar in the form of manuscripts that pre- and post-date the Kuthodaw recension, such as the Phayre manuscripts at the British Library reportedly dating to the early 1840s (Oldenberg 1882: 59), the several printed editions produced on the basis of the Fifth Council text, such as the Hanthawaddy edition (late 1800s to mid-1900s) and the Sixth Council edition (1950s). As our preliminary research mentioned above shows, it is anticipated that this research will help reveal the dynamic and changing nature of these texts, which have often erroneously been viewed as static, and the degree to which monastic redactors were willing to alter the wording of canonical texts.

Another aim of the project is to understand why King Mindon had the Pali canon carved on marble stelae in Mandalay, the context for its production, and what his models were. Particularly important in this regard will be understanding the role British territorial ambitions played in Mindon's decision to create the Kuthodaw Pagoda site.

Further aims are to produce an accurate account of the history of the Kuthodaw Pagoda site and to situate it within the broader context of the history of Buddhism in South and Southeast Asia, and to understand the role the site played in the construction of similar sites in Myanmar and other Southeast Asian countries at which Buddhist texts were carved on stone.

It is anticipated that this project will open up a whole new area of investigation, namely, the study of the Kuthodaw Pagoda, one of the most revered cultural and religious sites in Myanmar. In making the Kuthodaw text and related documents available to textual scholars, historians and the general public, it is anticipated that it will invigorate the study of the nature of the intra-regional textual transmission of Buddhist texts in Myanmar and in South and Southeast Asia more broadly. Based on this project's assessments of the nature of the Pagoda texts, this inscriptional witness from the mid-nineteenth century can begin to take its place alongside the currently unchallenged foundation sources for Buddhist studies, namely, the European and Asian printed editions of the Pali Buddhist canon which date mostly from the twentieth century.

By undertaking the cleaning of the inscriptions (a prerequisite to photographing them) and by producing a conservation and management plan, this project is assisting the Myanmar authorities fulfil their obligations towards this UNESCO listed site and will ensure that this historically and religiously important site is preserved for future generations. These ends will be furthered through the images of the inscriptions and the transcription of the text being made publically available, and through further study of the inscriptions, their history and influence by project members. In this regard, it is hoped that this project may act as model for the conservation and study of other significant monuments and historical resources in Myanmar.

Finally, because of the above joint achievements, this project will further Australian-Myanmar partnership and relations.[26] The project has been very keen to develop local conservation and site management skills in Myanmar, to employ local professionals wherever possible, such as our Mandalay-based photographer and the Yangon-based company that tested

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[26] This is the aim of the Australia-Myanmar Institute and the reason for it organizing the conference it hosted at which this paper was presented (see first page).

3D scanning, and to engage Sitagu International Academy monks to undertake the transcription project. The project may also be a unique example of Australian-Myanmar-Japanese co-operation, since the phase of the project outlined in this paper is being supported by Japanese funding. The Kuthodaw Pagoda Project's work has, in fact, already featured in several media articles, including the local Mandalay Burmese language newspaper, the *Yadanabon* (7.7.15, pp. 1, 19; 14.7.15, p. 5) and the *Democratic Voice of Burma (DVB) TV*, aired on Myanmar TV on July 30 [Fig. 17].

Fig. 1　Kuthodaw's main pagoda

Fig. 2　Stelae pagoda housings

Fig. 3   A typical stela

Fig. 4   King Mindon (reigned 1853-1878)

Fig. 5　A monk giving a sermon under a starflower tree

Fig. 6　Donative inscriptions

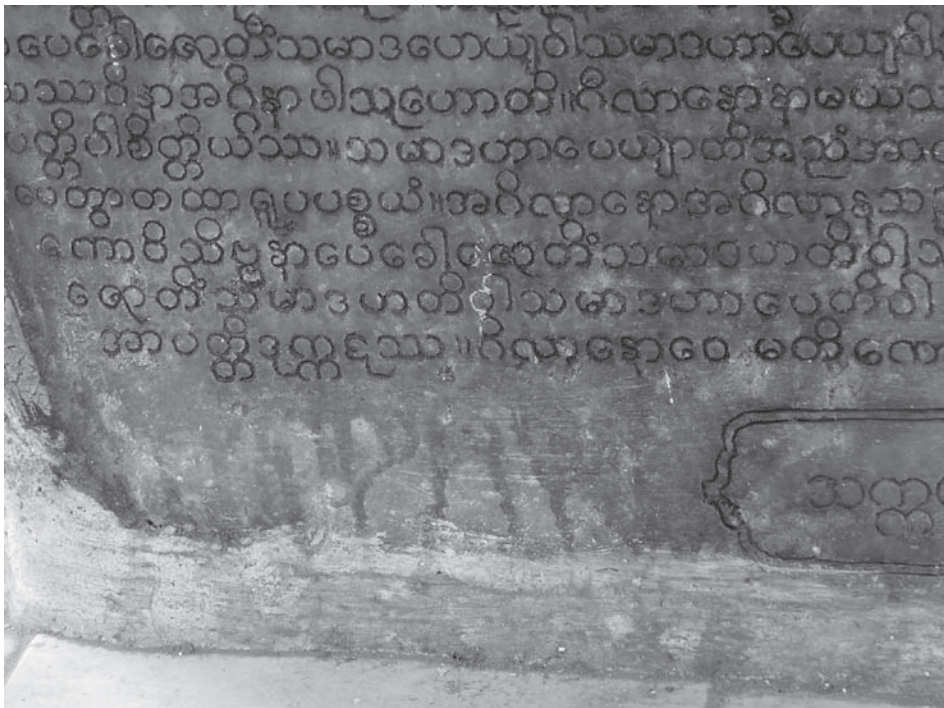Fig. 7   UNESCO Memory of the World plaque

Fig. 8   Stelae coating

Fig. 9　Vegetation on and overhanging a pagoda

Fig. 10　Vegetation overgrowth

Fig. 11   Reade treating whitewash

Fig. 12   Broken grille door

Fig. 13　Damage from bat droppings

Fig. 14　Department of Archaeology conservators Daw Su Hlaing Htay &
Daw Khin Swe Nwet at work

Fig. 15   Allon and the site manager U Wai Lwin inspecting a cleaned stela

Fig. 16   Testing the Artec Spider scanner

Fig. 17　Australian team members Bob Hudson, Mark Allon and Chris Clark with Department of Archaeology Mandalay conservators Daw Khin Swe Nwet, Daw Aye Aye khine, and Daw Su Hlaing Htay, 2014.

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