

Condition Survey of Nine Rock Carvings

A study of the condition, management and treatments of nine sites within the Hong Kong autonomous boundaries.

Prepared for the
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1. Executive Summary

Nine sites, located around or close to the Hong Kong coastline have been inspected in October 2009 to assess their condition and preservation needs. This report documents the findings of a survey conducted by Andrew Thorn of ARTCARE, based in Melbourne, Australia, who has specialized in the preservation of indigenous paintings and engravings on outdoor rock surfaces for more than two decades.

This report is in response to a specific contract setting out the requirements but which has allowed a high degree of freedom in how the sites are assessed and the findings presented. In essence this report operates as a supporting guidance document to aid in the better preservation management of the sites.

All sites are located in proximity to the sea with several within the spray zone, with the more distant still within 1.5 km of the coast. Six sites are within exposed rocky settings and three set in shaded woodland, offering some amelioration from direct sun impact. All sites have had substantial infrastructure built to both facilitate access and protect the sites from visitor impact. In most cases the access infrastructure is achieved through pathways and steps poured in Portland cement concrete, which has also been used to create water diversion dams and cappings. Much of this infrastructure is several decades old and while there is no manifest impact on the engravings, the heaviness of the structures and the potential for damage requires some consideration on how to better present and protect the sites without relying on this material.

In recent years several preservation treatments have been applied to the surfaces and all of these are conventional modern day conservation treatments, supported by copious international literature. Part of the function of this report has been to assess these treatments, both in terms of their selection and more importantly their application to the sites. Some recommendations have been made on how to fine tune some of these treatments and this is seen to be an important part of the supportive relationship inherent in this commission. The author is no better able to make decisions about deterioration and remediation but does bring a fresh set of eyes to the situation and can speak with confidence about current international practice in relation to the preservation of exposed rock surfaces.

The relatively recent application of most treatments means that long term performance cannot be evaluated at this time but a process of evaluation has been outlined and has already been in place since treatments first began in 2004 and prior to this report.

The overall condition of the sites is one of stability. This is a general statement as it is clearly understood that no rock is ever stable. What can be said is that the conservation team are aware of these limitations and know that carefully selected treatments can slow natural erosion. This can only be achieved however through regular and sustained monitoring and the timely maintenance of applied treatments. This process appears to be in place.

The sites are all open to access by unguided casual visitors but protected by screens or grilles. Open access requires considerable protection and it is in general preferable to have sites accessed under supervision. This is the case in many parts of Australia where indigenous custodians lead visitors to their sites. Tourism has been identified as an important part of managing the sites and this requires careful consideration of not only the needs of the sites but also of tourists to ensure they have a positive experience. Currently all nine sites are available for visitation and all have protective barriers. It could be argued that at least two of these provide very little visual stimulus for the casual visitor. Their downgrading to recorded but undeveloped sites would not threaten their longevity. People seeking out such less obvious sites will, on the whole, be respectful and unlikely to cause damage and hence infrastructure is not required. In fact the infrastructure is more likely to attract negative impacts and serves as a marker to these sites. It is believed that a rich visitor experience for up to two days can be achieved through promoting fewer sites, no more than three site are required for a one day tour. These sites should be identified and upgraded with modern low impact access and separation barriers.

The current screens, roofs and barriers do not, on balance, provide superior protection to more discreet methods. It is recommended that Portland cement infrastructure should no longer be used and that ultimately it be removed from the sites. Achieving a more natural setting will enhance the reading of the engravings and overall visitor satisfaction. There is a need to consider the destructive impact of typhoons in determining what light weight access options are available.

In summary the sites are moderately stable. Treatments are appropriate, subject to minor refinements. Management and monitoring appears to be well supported but there is an overall need to reassess the appearance of the sites with reference to the setting in which they were first created, knowing that bringing visitors to sites does not easily allow for a safe return to an unprotected state.

2. Introduction

2.1. The brief

The contract between the Government of the Hong Kong Special Administrative Region and Artcare has defined the consultancy service requirements to include a thorough survey of the current condition of the nine known sites located within the Hong Kong autonomous boundaries. The study has been required to assess three distinct aspects of the sites. Their current condition; management and tourist infrastructure; and treatment methodologies and practices.

2.2. Consultation

The consultant has had an initial meeting with all relevant staff and informal discussions about the background to the carvings.

2.3. Custodial Group

Discussions with the staff of the Antiquities and Monuments Office have confirmed that the engraved sites in this study are not more closely aligned with any particular modern day group. They can be considered common heritage to the region and made by people quite possibly still living in the region. No modern day tribe, sect or group claims closer ties to these sites than any other Hong Kong resident. To this end it has not been necessary to liaise with custodians beyond the Office staff who have modern day custodial responsibility.

2.4. Similar studies

The writer has undertaken more than 400 site surveys at indigenous engraving and painting sites located on exposed rocks or within shelters and caves. These surveys have been undertaken since 1988 and have allowed the writer to gain a sense of what are the key relevant features of a site that affect its longevity. In parallel with this the writer has worked on the preservation of stone since the late 1970s, maintaining an active engagement with the profession and current technologies. Through the offices of the Conservation Committee of the International Council of Museums the writer has been variously co-ordinator of the Rock Art, Stone, Murals Stone and Rock Art, and Resins Evaluation Working Groups, necessitating an active engagement with developments in each of these inter-related fields. Similarly the writer has researched and published on environmental evaluation and controls for outdoor environments and stone objects in situ.

Funded research projects have included Salt erosion, Moisture stability of pigments and related minerals, Solar impact modelling, hydrothermal stress and most recently the Consolidation of water saturated volcanic lava and tuff.

2.5. Terminology

Carving / Engraving/Petroglyph In this report the terms carving and engraving have been used interchangeably. The client has preferred the term carving to describe the sites. In general international rock art literature prefers the term engraving or petroglyph to describe a motif that has been pecked into

the bedrock resulting in a lowering of the surface to form the motif. Carving on the other hand tends to imply the removal of the background rock to leave the motif as a raised surface. All of the sites inspected conform to the description of engraving and there are very few true carvings found in the context of outdoor rock art sites. Most notably the Te Ana a Maru carved site in New Zealand and several individual motifs in French caves can be classified as carvings because they stand out from the background rock.

Petroglyph is a term that describes all markings in stone and is a more general term. No doubt there is a more appropriate term in local languages to describe the sites.

Preservation / Conservation / Restoration

The terms preservation and conservation and their derivatives are used interchangeably in this report and distinguished from the term restoration.

Preservation is considered here to mean direct and indirect intervention that does not alter the appearance of the surviving object. Conservation for this report describes the same range of actions and it is debatable whether such actions as water repellent treatment are conservation or preservation. For this report it doesn't matter which term is used. Restoration by contrast describes the act of reconstructing missing parts or in some way intentionally altering the appearance to return the object to what is believed to be a truer appearance. Restoration is seldom considered necessary or desirable for archaeological materials and is not advised within this report.

3. Geological setting

An overview geological map of Hong Kong shows it divided largely between granitic and volcanic rocks with the nine sites all located within volcanic formations. More detailed maps reveal a more diverse geological setting and accurately show that Po Toi for example is located on what is described as a basalt band lying within a coarse grained granite. The site at Joss House Bay, by contrast, appears to be a reformed granite boulder containing phenocrysts of older basalt. This is not indicated on the relevant map, which only describes the background hill slope.

The need for precise geological classification of each rock type has implications for treatment and general decision making. It is also an important part of the background description of a site.

Granitic rocks are very dense whereas volcanic types such as tuff and eutaxite are considerably more porous. This has implications not only for issues such as weathering resistance and saline moisture absorption, but also how treatments will be absorbed and impact on their resultant durability. A granite surface will not require a great deal of consolidation and nor will it readily absorb such treatments. Volcanic rocks on the other hand are highly porous and while they will absorb copious amounts of consolidant this will not be as effective after one treatment as a wholly siliceous sandstone or similar rock. Thus for one rock type there is a danger of over consolidation to the extent of forming a glassy surface while for the other a high loading of consolidant will not change the surface appearance but nor will it necessarily achieve the desired consolidative effect in one treatment. Tuff responds very slowly to ethyl silicate consolidation and may require a treatment program over several years to achieve significant stabilization. It has been very difficult for the conservator to understand the nature of the rocks at each site and the geological map has not been entirely informative about this either.

4. Condition of the Sites

Each site has been inspected to assess the general condition. The Condition surveying methods have been those routinely employed for first assessments. That is the survey relies largely on visual assessment with no sampling or off site analysis. The field survey has benefited from the occasional use of a field microscope but this has been limited to gaining a clearer understanding of rock constituents and characterization of residues and deposits within the surface. No electronic assessments have been carried out for salt or moisture distribution and no background research conducted on the geology or climatic

data. Where the site is partially shaded a solar map has been prepared to illustrate the shade benefit and in some cases provide recommendations for further shading.

In summary all sites have been found to be generally stable with the exception of that at Cheung Chau that appears to have recent impacts from water seeping from the garden beds in the property above. The other sites are subjected to natural erosion but not at accelerated rates and certainly not due to modifications to the sites in recent years. All impacts and issues are discussed in detail within each site form.

5. Assessment of treatments and modifications

The Office has been entrusted in recent years with the care of these sites. This has been handed over from curatorship by other museum and has led to a systematic treatment program. It is clear that intervention by the Office has been based firstly on diagnosis and secondly on treatments developed and used throughout the world for addressing the identified problems. Various press reports in recent years have been critical of such intervention and this section attempts to objectively assess the treatments and their impact on the sites. The following table summarises all treatments and potentially impacting site modifications noted on the site forms provided to the author.

Table 1 Summary of site interventions and potentially impacting management implementations.

Site	Impacting Management implementation	Interventive treatment
Big wave Bay	Roof in 1991, previously caged, glass removed in 1995	2008 Cleaned with surfactant
Cheung Chau	Glass structure built in 1986	-
Joss House Bay	Screen installed in 1983	2006, surfactant clean, bio suppression, siloxane hydrophobe
Kau Sai Chau	1978 cage replaced with s/s in 1986	Removal of plants
Lung Ha Wan	Glass screen in 1984	2006 Brush cleaning, ethyl silicate consolidation, siloxane hydrophobic treatment
Po Toi	1984 glass screens, chain fence temporary repair in 2009. Water diversion not cited	Surfactant clean 2004,2007,2009 Biota suppressant 2007 Siloxane hydrophobe 2007
Shek Pik	1985-92 polycarbonate screens, replaced by open caged, roofed structure	2005 surfactant clean
Tung Lung	1983 polycarbonate screen	Surfactant clean in 2006
Wong Chuk Hang	Slope protection in 1987	2006 surfactant clean and moss removal, biocidal treatment, siloxane hydrophobic treatment.

5.1. Impact of shelters, pathways and water diversion.

Earlier work appears to have been confined to infrastructure changes, such as the building of cages, shelters and access pathways. This will all be discussed here as well as in the management section. The discussion here is confined to how the infrastructure influences or threatens stability.

The main considerations are;

Shelters – alter the deposition of salts and their subsequent washing from the surface by rain.

Pathways – most have been formed from massive concrete installations. Portland cement concrete releases very high levels of a range of soluble salts. The most damaging of these are the sodium sulphate suite but include less soluble obscuring salts such as gypsum.

Water diversion and slope stabilization – Concrete has been used above the engraved surfaces to divert water, prevent its entry into fissures, and in one or two sites to stabilize the hill slope above the site. All of these introduce Portland cement and its potentially damaging salts

5.1.1. Shelter design

Shelters of various designs have been constructed over the years to protect the engravings, largely from visitors but also to provide some protection from natural forces. The main impacts of concern, other than humans, have been sea spray deposition of salt, and whether the enclosure will encourage biological growth by excluding ultraviolet light (UV).

While the shelters have various forms they are considered here as having the following features in relation to the naturally exposed rock;

- Reducing insolation
- Reducing salt deposition from sea spray.
- Reducing rain washing of the surface and any accumulated salt.
- Protection from adverse visitor impacts
- Changes to the biota through reduced moisture and reduced UV and other light.

Reduced insolation (sunlight)

Insolation is the preferred term to describe sunlight on rocks as it is misleading to talk about light, whereas the hydro-thermal stability of a rock surface plays a very big role in erosion. Recent studies by the author (Thorn 2008) have demonstrated that a combination of wetting and drying can generate much higher stresses in sandstone than heating or wetting alone and greater than the more broadly discussed freeze thaw mechanism. It is important to emphasize that this study relates to a specific sandstone and may not translate directly through to other rock types. An understanding of the physics of the relevant crystals indicates however that the indications from sandstone will have relevance to all silicate rocks but less so with calcitic rocks.

Thermal stress will be reduced substantially by shading a rock surface. The heating and cooling behaviour of rocks exposed to direct insolation is determined to some extent by the heat absorbing character of the surface, the albedo, that can see some rock surfaces reach 60-70°C during the day and cooling to air temperatures over night. Unpublished studies by the author suggest that the surface of an intermediate toned sandstone will consistently reach 1.7x air temperature. This means that a 40° day will allow a surface to reach 68°, which will return to the minimum ambient temperature just before dawn. An overnight minimum of 20° provides a diurnal range of almost 50° whereas a fully shaded stone will have a diurnal range of just 20°, the difference in air temperature alone. Various authors have implied that damage to stone will occur at a diurnal range of 30° or greater. It is quite clear from this that shading, either in the form of trees or a roof such as those at Big Wave Bay and Shek Pik will reduce thermal stress. A roof also excludes rain and this is far more beneficial given that wetting and drying has been measured to produce a substantially greater stress. These assessments need to be weighed up against visual intrusion, which in itself can be accommodated provided the site is not visually dominated by such structures. In terms of thermal stress the more traditional roof structures mentioned here provide greater protection than the glass screens found at other sites. It cannot be assumed however that the glass screen will increase thermal stress. This is a complex issue and should not be speculated upon without direct measurement.

Sea spray – Rain wash

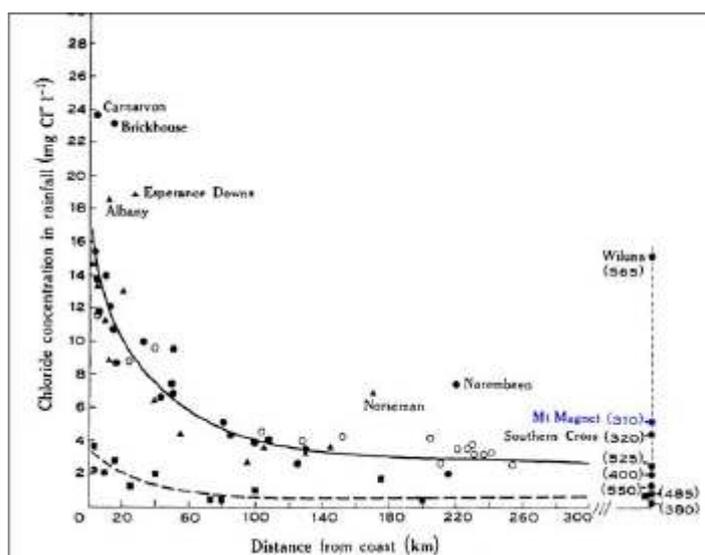
Glass screens have been installed across the front of many engravings with the primary function of reducing human impacts such as graffiti, soiling and impact damage. These screens appear to provide this benefit and there are several instances of graffiti bear to protected surfaces. The secondary benefit cited is that of reducing salt deposition at sites within reach of the sea. Po Toi and Tung Lung are two obvious examples of sites within reach of crashing waves but many others are close enough to receive airborne salt deposition. Studies of salt deposition in Australia show that regardless of sea spray there will be very high salt deposition across all sites and that the biggest factor reducing these levels is vegetation cover.

Equation 1 Chloride distribution v. distance from the sea.

$$Cl^{-} (\mu eqL^{-1}) = \left(\frac{0.99}{4d}\right) - 0.23$$

where d = distance from sea.

Figure 1 Salt deposition v. distance from coast in Western Australia (from Hingston and Gailitis 1976)



More important than salt deposition is the ability of rain to flush the surface. Frequent rains will wash salt from the surface and prevent excessive accumulation. Salts are present in the air at high levels near the sea and do not depend on sea spray for deposition onto a porous surface. With the salt deposition mechanism, roof structures are potentially more damaging than screens that allow flushing of the surface. The roof will not impede aerosol deposition but it does eliminate flushing, leading to an unnatural accumulation of salt. Having said this there is no evidence of salt accumulation in either of the roofed sites.

The screens themselves may block some salt deposition but it is naïve to believe that they provide better protection from salt damage. Where the screen prevents washing (Cheung Chau, Tung Lung to a lesser degree) this should be seen as less desirable than those that do allow rainwater to wash the surface (Po Toi). The application of water repellents is beneficial in preventing salts being drawn into the surface by moisture and still allows water flushing to operate. To this end water repellent treatments overcome some of the shortcomings of a sealed screen.

Sodium sulphate is the salt chosen for accelerated weathering studies due to its ability to rapidly damage porous materials. It is also the most abundant soluble salt released during the curing of Portland cement concrete. There is very little evident damage from the use of Portland cement but enough to review its use and to find alternative materials where contact or close application to engraved motifs is necessary.

Adverse visitor impact

Visitor impact is more properly addressed as a management issue but there is no doubt that the screens and pathways have been placed largely due to visitation. The impact of pathways will be dealt with in more detail elsewhere and the only issue having impact directly on the engravings is mineral enriched water. The screens and grilles have been installed to prevent direct touching in some cases and to prevent graffiti. The glazed screens, either of glass, polycarbonate or perspex, make viewing of the engravings more difficult and alter the natural setting in a substantial way. It is difficult to determine to what extent the sites are subject to vandalism although there is evidence of painted markings on rocks nearby. Screening of cultural sites for protection can often provoke a response that would not otherwise have occurred. This will generally be off the site due to the protective barrier but will have impact on the natural setting surrounding the site. More importantly such impacts require funds to rectify. The current arrangement at Po Toi where one panel of engravings is protected by a screen and the other by a low chain fence will serve as a useful study in current attitudes and behaviour. The chain fence has only been in place for less than 12 months but to date has received no adverse impacts. To reduce the risk further additional signage is recommended. This should be informative and engage the visitor as part of the management team. A fuller discussion of this is presented in section 6.3.

Biota balance

Biological growth over rocks is generally seen as a negative impact and there is a vast body of literature to support this view. One slight downside to all of this literature is that it seldom ranks biological impact in relation to others such as hydrothermal and salt erosion. A diversity of opinion seems to prevail about the good and bad of screens in relation to salt and biota and it is quite clear that these two requirements contradict each other, if the opinions expressed are all valid. The argument for screens in relation to salt deposition have been presented above with a conclusion by this author that screens will reduce direct deposition but that aerosol deposition still continues. The more important issue is that of flushing to ensure that salt does not accumulate to damaging levels.

The arguments for biota in relation to screening are more complex and thus require a deeper discussion. One argument that has been put is fine in theory but needs to be expanded upon either through observation or greater theoretical substance. It has been stated that screens will exclude UV light, the presence of which controls biological growth. This much of the statement is true – biological growth will cease if UV is of sufficient intensity. That screens will in some way alter the UV level and that a reduction will lead to manifest growth is not a statement that can be so readily upheld.

Two intertwined questions need to be addressed.

- What portion of the UV spectrum suppresses biological growth?
- Does the screen filter this part of the spectrum?

Sunlight arrives through the atmosphere within the spectral range 295-750+ nm while visible light begins at around 400 nm. So the complex question is how damaging is the UV spectrum in the range 295-400 nm and how much of this is excluded from the rock surface by a glass or acrylic screen?

Bacteria suppression is effective with UVA (315-400 nm). Lichens have the ability to provide a protective covering to counter sunlight derived UV. Non specialist glass will transmit all wavelengths above 350 nm while regular acrylic sheet (Plexiglas, perspex) will allow all wavelengths above 370 nm. Acrylic will obviously exclude more UVA than glass but both allow enough through to provide impacts of the same type as unscreened surfaces, albeit at a much reduced dosage. The exclusion of UV through screening is minor compared to that achieved through vegetal shading.

UV growth suppression is not the only factor in biological growth, in fact it is secondary to water supply. Regardless of light exposure a reliable water supply will promote biological growth, a fact illustrated at every place where water wash is evident at all sites. Hence it is important to consider the total environmental changes that may be induced by screening; both UV and water reduction. On balance there may be some sites where the balance favours growth and others where the opposite is the case. The final assessment comes down to observations at the sites themselves. This can only be effectively assessed through photographs taken over a ten year period or longer. It can also only be done at those site where hydrophobic siloxane treatments have not been applied. The former screen at one panel at Po Toi has recently been blown away by a typhoon. Inspection of the site shows no clear line between the rock surface that has been screened and that always exposed to UV.

Table 1 indicates that only Cheung Chau has a glass screen and no recent interventions that would alter the biological development over the lifetime of the screen. This site is complex due to the fact that it has had Portland cement cappings added and is currently subject to seepage from fertilized garden beds above. Yet even looking at the site critically to try and establish evidence of biological enhancement, it is very difficult to state that this site displays an increase in biological growth when compared to its surroundings outside the structure. There is evidence of condensation on the roof members, indicating that the environment inside the structure is conducive to growth and yet there is no clear evidence of accelerated growth. The engraved panel is clear of any growth but has remnant green paint which may indicate that some treatment has been applied to remove a green paint layer at some time. This treatment would have removed any biological growth.



Figure 2 Cheung Chau – There is slight evidence of biological growth inside the structure (left) but nothing like that growing outside the enclosure where water supply is ideal for growth and full shading from the sun.

Figure 2 illustrates the difference between an internal environment with reduced water and UV and one that has high water supply and complete shade. It is the latter situation that will lead to manifest biological growth. There is no evidence within the structure to indicate a proliferation of biota other than where seepage from the gardens above has created a distinct path of not only biota but salt erosion.

It is important to emphasize that changes to the water supply will be far more significant than UV suppression. The application of the siloxane water repellent to several sites will ensure that no biota can be sustained on these surfaces while it remains effective. This is not a justification of this treatment at this point however the merits of all treatments are discussed in other sections.

An increase in biological growth is easily controlled using ethanol, as described in other sections.

5.2. Treatments applied to the engravings

Table 1 gives a summary account of the range of treatments applied to the sites in recent years. These treatments have been consistently applied with no variation in treatment material for each problem addressed. The treatments can be summarised as follows;

Table 2 Summary of treatment interventions, 2004-2009.

All of these treatment approaches are standard conservation treatments and have been applied in normal conservation methodologies. The following section is not a critique of the treatments necessarily, although some direct comment is inevitable, but is more a third party assessment of the issues and how this author would address the problems.

Problem	Treatment	Material used	Application sites
Dust and debris	Dry brushing	Bristle brushes	BWB, JHB, LHW, PT, SP, TL, WCH
Surface soiling	Surfactant aided wet clean	Decon@90	BWB, JHB, PT, SP, TL, WCH
Biological growth or staining	Biocidal wash	Remmer BFA isothiazolinon	JHB, PT, WCH
Water flow over surface, air pollutants, pests	Water repellent	Remmer SNL siloxane	JHB, LHW, PT, WCH
Friable stone surface	Consolidation	Remmer 300 ethyl silicate	LHW
Portland cement staining	Cement dissolution	Acetic acid, diluted	PT
Sites with no treatment applied to date CC, KSC,			

Dry brushing

This is a perfectly safe practice provided a condition assessment is made of the friability of the surface. There has been no evidence of highly unstable surfaces to warrant concerns about brush impact. One consideration that should be included here is the need to use natural bristle rather than synthetic brushes. While both forms have the ability to contaminate the surface, bristles break away in short segments, whereas synthetic fibres become smeared across the surface as they wear. Bristle fragments will not remain for long but the smeared synthetic material will limit dating potential and generally contaminate the surface.

Surfactant cleaning

In general it is preferable to avoid the use of detergents and surfactants. They are very difficult to clean from the surface completely and do not break down all that quickly. Surfactants can attract dust and provide altered surface conditions. If the surfactant is being used to provide better wetting for the surface this can be equally achieved by pre-wetting with an ethanol rich solution. Once the surface tension has been broken initially water will be readily absorbed onto the surface. Generally a light spray with ethanol and water 1:1 will provide good absorbency for water washing.

Biocidal treatment

Biocides act by providing a lethal short term dose with sustained suppressant action for as long as residual toxin remains on the surface. On an exposed rock surface the residual toxin will be removed quite quickly through washing and UV degradation. Recent unpublished studies carried out in Sweden and confirmed by the author at sites in New Zealand and Australia have shown that ethanol or industrial methylated spirits will have a very effective biocidal impact. The initial toxic effect is as rapid as that of organo-tin compounds and the thiazole used at these sites. The residual toxicity of ethanol should be similar to thiazole unless the latter has a binding agent, and both will be less durable than organo-tin compounds. It is important to know whether the applied product is purely a liquid or has binding agents. Commercially available organic toxins such as glyphosphates contain both surfactants and binding agents to ensure the toxin attaches and remains on the plant.

Initial toxic impact is just one feature of the ethanol method. Biota re-establishment is the determining factor in the success of any management program. A treatment that is very effective initially is less successful if it only provides residual suppression for a short time. Once the residual toxicity has been diminished the biota are free to re-establish. The quickest means of re-establishment is through culturing in the former biofluid remaining undisturbed by most toxic treatments. Ethanol has the ability to disrupt the biofluid and remove it from the surface.

It is proposed that the conservators caring for these engravings institute a test program using the ethanol method. The approach advocated by Eva Ernfridsson in Sweden is to spray the surface three times at 21 day intervals, although a recent successful treatment applied both two and three applications within the one site with similar results for each. Comparison between the current approach and ethanol will establish the ongoing cost and viability of each.

One of the absolute requirements of biological persistence is a constant water supply. The application of the siloxane water repellent will ensure that for the life of this treatment, biological growth will become dormant. This method has been documented by the author as one of the most efficient means of suppressing the regrowth of biota in those situations where it is certain that moisture does not flow through from inside the object. The use of siloxane for any treatment needs to be preceded by a very comprehensive study of water migration to ensure that no water enters the rock elsewhere and requires the treated surface for its evaporation.

There are environmental benefits of using ethanol. It is a solvent of relatively low toxicity and has no long lasting impact on waterways and animals. It is moderately safe for human use and relatively inexpensive.

Water repellency

A conference sponsored by ICCROM in 1994 focussed on the need to stabilize the Moai, the standing statues of Easter Island. Of the many papers published (Charola, A.E., Koestler, R.J., and Lombardi, G. eds.), drawing on studies from every part of the globe, the recommendations were unanimously in support of the use of ethyl silicate for consolidation followed by water repellency. In many instances the preferred water repellent was a hydrogen functional siloxane. The main point here is not to endorse a particular approach but to observe that diverse studies of tuff and lava have led to the same conclusion that water repellency plays a vital role in stabilizing exposed rock subject to wetting and drying.

Siloxane has been applied to four of the sites and according to the conservators responsible has been applied as a pure solution as supplied. This is generally a far higher concentration than is required to achieve a durable water repellent treatment and yet there is no evidence in 2009 of darkening of the surfaces studied. Darkening is usually the determining factor for concentration and typically begins to become an issue above 15% siloxane. The treated surfaces do not appear to be unduly darkened but this can only be fully established by comparison with photographs of the site before treatment. In general the treated areas have become visible but this is more through a lighter cleaner surface, brought on partly through initial cleaning but more so by the fact that the siloxane inhibits biological regrowth. There was evidence at two sites of a thick scaly deposit in the deeper pits in the surface and these are most likely the remains of the siloxane that has cured on the surface without penetrating into the rock. The author has limited experience with using the siloxane in undiluted form so it is difficult to say whether this is the case. This scaly deposit is easily removed and does not constitute an irreversible alteration to the surface and only noticeable on very close surface inspection.

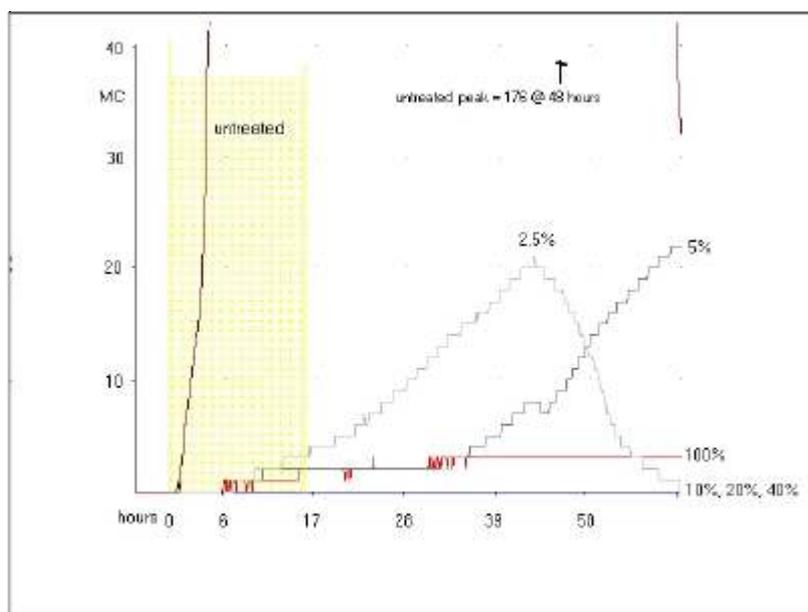


Figure 3 Various concentrations of siloxane and their response to atmospheric humidity. (From Thorn 2005)

The author has used siloxane to stabilize clay pigments on indigenous rock paintings and the relevant article is attached to the electronic version of this report. The following chart has been extracted from the research to indicate the relevance of dilution on hydrophobicity. This study is confined to clay minerals but has some direct relevance to the matrix of volcanic rocks. Figure 3 shows that concentrations as low as 2.5% are capable of repelling water for 6

hours and that those of 10% and greater can do this for a suitably long period. Curiously in this study the 100% siloxane was less effective than diluted treatments between 10 and 40%. In practical terms rock painting pigments are unduly darkened at 20% and some surfaces can be affected at 15%. Conflicting with this is the understanding that higher loadings will impart a longer lasting repellency and thus the balance between surface colour stability and longevity needs to be found. The Easter Island papers have studied longevity and indicate that siloxane repellency will survive for 8-20 years but these observations do not relate loading to durability. It is believed that the lesser performance of the 100% siloxane in Figure 3 is due to poor penetration of the more viscous liquid into the porous surface but this observation remains unsubstantiated. It may however be the reason for the crusty residues present on two of the engraved sites.

Siloxane can be diluted with any miscible solvent with white spirit used most frequently by this writer. More polar solvents give better penetration but white spirit is readily available and very slow evaporating. It is possible to mix siloxane with ethyl silicate as a combined treatment in those cases where consolidation is also desired.

A test application on a clay rendered wall near Melbourne Australia was examined after five years. After that time the treated test area stood 2-3 mm clear of the surrounding surface, indicating that the untreated surface had been eroded by that much in five years. This dramatic improvement will not be replicated in harder materials but does illustrate the benefits of keeping water off water sensitive surfaces.

The site cards refer to the siloxane reducing air pollutants and pests. These will only be reduced if they are dependent on water, which will be the case for the reactivity of pollutants on the surface. It is less clear what impact siloxane will have on pests.

Consolidation of friable stone

One of the most difficult tasks in searching the conservation literature is in finding examples of damage to siliceous rocks as a result of applying ethyl silicate. As previously stated it has been unanimously determined to be the most effective means of strengthening the volcanic rocks of Easter Island and has hundreds of documented applications on silica based rocks. It is possible to find examples of where the treatment has not been successful, as opposed to causing further damage, but these relate to applications to lime plasters, adobe walls, and in the past few days an example at Ajanta Caves in India where repeated applications have resulted in a darkened surface. Oddly enough, and to illustrate just how inappropriate and naïve some applications can be, the ethyl silicate was applied at Ajanta to provide water repellency. Ethyl silicate is successful for the very opposite reason to this in that it does not retard moisture once fully cured. It does however go through a curing phase that renders the surface water repellent for up to two months.

The ethyl silicate application can only be assessed by this writer at Lung Ha Wan in terms of the resultant durability and surface appearance. Both are fine and it is safely assumed that conditions warranted the treatment.

Application of ethyl silicate can measurably alter the porous nature of a rock but not to an extent that changes its fundamental ability to allow water to pass through.

It is this writer's view that ethyl silicate can be applied to any of the sites inspected provided conditions demand such treatment. On the whole friable stone was not encountered except at Cheung Chau where what appears to be saline erosion is occurring as a result of water flow from garden beds above. Further study of this damage is required to assess salt distribution and damage, before any treatment is implemented. It can confidently be stated however that any friable stone at Cheung Chau should respond well to ethyl silicate consolidation provided salt levels are not high.

Portland cement dissolution

Portland cement mortar and concrete contains a range of varying soluble and insoluble minerals. The final product is largely composed of various alumino-silicates insoluble in water. The one component that can be dissolved is calcite. This is sparingly soluble in water but highly soluble in acids. The main question to answer when choosing an acid to dissolve calcite is not which is better able to break up the mineral but rather what salts will be formed from any residual acid. Acetic acid has been chosen and this is one of the preferred acids employed. Coincidentally and with no comprehension of its use at Po Toi, the author had recommended its use during the project to remove a possible lime coating from a mural painting inspected on the last day of this project. No acid can be considered safe and appropriate, hence a great deal of caution and testing is required. In terms of Po Toi the benefits of removing the cement splatters outweighs any subsequent impact on the surface. If the rock is basalt, as the geological map indicates, then there is very little soluble material contained within. Biotite or other iron minerals may be more soluble in acidic conditions possibly leading to a higher than normal release of soluble iron compounds. There was no evidence of alteration as a result of acetic acid use at Po Toi. The same treatment has been used by the writer for the removal of cement slurry from sandstone headstones and for that project each acetic acid treated stone was followed up with an ethyl silicate consolidation just to ensure that no cohesion was lost through calcite dissolution in the cleaning process. The sandstones in question contained some calcite and thus the precautionary treatment was more sensible than it perhaps might be for Po Toi.

5.3. Older treatments

Of the earlier site management procedures, those that have direct impact on the sites include the installation of diversion drains and the capping of openings to prevent water entering into the rock behind the engraved surface. Both of these interventions rely on the use of Portland cement, as does much of the access infrastructure. It can be seen at several sites that the use of Portland cement has been excessive and clumsy, resulting in splatters onto adjacent surfaces. The removal of such splatters has already been undertaken and described in the preceding section. In the case of the diversion dam walls and cappings the main concern here is that several of these can be seen to have been breached at various times and that others have required repair. At Cheung Chau and Po Toi, two sites where the application of Portland cement has been perhaps the most indiscriminate, staining and salt runs are visible emanating from the cement application areas. Portland cement contains several highly damaging soluble salts and should be viewed as a substantial threat to the stability of the engraved surfaces. Such damage can be seen at the base of the screened panel at Po Toi. Any breaches of the diversion walls will spill salts into the cultural area. It is strongly advised that Portland cement be excluded from any future site activities. Diversion dams can be built from ethyl silicate based grouts such as those supplied by Remmers or manufactured in house. Both ethyl and lithium silicates can produce grouts providing durable and non damaging water diversion walls and capping materials. These grouts are better formulated locally so that local materials can be incorporated into the aggregates to provide a better colour and texture match. The formulation of these grouts will be described in section 5.4 below.

A Portland cement capping grout has been applied to a large detaching area within the screened panel at Po Toi. The grout provides no adhesion for the detachment and has reached a point where it no longer keeps out water either. Fortunately this detachment is within the screened surface so water entry has been reduced, however the point here is that Portland cement does not provide an adequate bond to rocks for long and has the potential for depositing salts inside the detaching area.

5.4. Treatments recommended

In general the treatments applied are all appropriate and have been developed through investigation, analysis and reference to current international literature. While the notes above indicate some means of refining or modifying application methods and materials, it can be said that the approaches taken all conform to modern practice. It should also be noted that the treatments have been applied in a cautious manner in that they began in 2004 with one treatment, two in 2005 and then increased to a total of 11 interventions in 6 years. This must be seen as a sensible rate of implementation ensuring that results are observed before the next treatment is applied. If one had to find fault with the program over the past 6 years it could only be in relation to siloxane application applied at 4 sites in one year. After 5 years however there are no adverse impacts from the siloxane treatment at any site.

5.4.1. Grouting of detachments

The Po Toi sheltered panel has a large detachment on its upper right side. This has previously been capped with Portland cement and sand but remains poorly attached to the bedrock behind. This is the most manifest example of detachment but there are other smaller examples located at other sites. It is recommended that in addition to the treatments currently being applied all detachments be reattached. The need for this is identified in each site record in following sections.

Grouts can be formulated from ethyl silicate or lithium silicate binders. An ethyl silicate grout can also be purchased from Remmers, named as supplier for several of the treatments described in the site records. The benefits of these grouts is that they have been designed to be perfectly compatible with siliceous rocks and contain none of the detrimental properties contained within the rocks or in other conventional grouts such as those based on lime and Portland cement. Lime grouts have found wide application in the preservation of fresco and plaster but the calcite remains mobile and can leach out to form gypsum on the surface.

Lithium silicate is a relatively recent conservation material with very little supporting evidence of its long term performance. Chemically it is quite stable with no likelihood of salt release. A grout has been developed by the author that is quite simple to formulate. Typically lithium silicate is supplied as a dilution in water in the range of 25% solids. The supplied product can be diluted to 5% (1.25% solids) and still form a moderately stable and well bound grout. The only issue so far has been strong brown staining observed both in the grout formulation and consolidated tuff blocks. This has been attributed to the very alkaline lithium silicate having a strong oxidizing reaction with constituents of the aggregate. The exact cause remains unresolved but pH adjustment to 8.5 and lower has eliminated the staining problem.

A typical grout that will impart satisfactory strength and provide water permeability can be formulated as follows;

- Lithium silicate, diluted with water to 20% of supplied product (5% solids), adjusted to pH 8.5 with acetic acid.
- Gel lithium silicate to cream consistency with fumed silica.
- Aggregates must commence with quartz flour in the range 5-200 microns, forming around 10% at least of the total aggregate. This results in a light coloured grout. Darker grouts can be achieved by substituting trass and this, mixed with quartz flour, gives intermediate tones.
- Local coarse aggregates. These should be chosen for colour and texture matching of the finished grout. Generally washed sand mixed with local crushed rock of the same type as the cultural surface can be used.
- Pigments can be used to make fine adjustments to colour but relying too heavily on pigments will give an artificial appearance that will never look convincing.

The grout should be applied in small quantities and built up in layers no thicker than about 10-15 mm. Each layer should be allowed to set for 4-6 hours with the emphasis throughout on pressing the grout into place rather than trowelling it on.

The ethyl silicate version is weaker and requires more careful formulation. The key requirement for a successful grout is to ensure that the ethyl silicate is gelled with fumed silica until it forms a stiff rubber like consistency. Typically 1 part of ethyl silicate with two parts fumed silica shaken together will result in the right stiffness. It is also more important to have the fine aggregate ratio (quartz flour and trass) correct as this grout relies very heavily on particle packing to achieve its strength.

These grouts, like all mineral grouts, provide very low tensile strength. Generally reattachment requires a higher tensile strength than rocks possess and thus it is advised that detaching pieces be secured with a high tensile strength adhesive to augment the bonding of the grout. Spot applications of adhesives that will not soften in the ambient conditions, are recommended. Epoxy resins are one adhesive that meets this requirement but this should be placed entirely below the surface and in discreet locations rather than as a solid layer between the detachment and parent surface. Once these support attachments are made the cavity can be filled using injectable variants of the above grouts. To make the described grouts injectable requires the removal of the coarser aggregates. This tends to give less cohesion and very little adhesion is achieved. The addition of up to 10% acrylic dispersion will increase the adhesive properties of these grouts and still retain a degree of water permeability, a desirable property of any grout reattachment.

Where water permeability is not desired, such as in the building of diversion dams, a higher loading of both liquid silicate and acrylic dispersion may be used, or alternatively the water side of the dam can be treated with siloxane to keep it water tight.

One of the strong features of these grouts is that they contain more or less the same mineral suite as the rock itself. Calcium is a nutrient for biological growth and it is important that the grout neither promotes nor retards the growth of biota, but rather allows new growth to re-establish at a similar rate to that on

surrounding natural surfaces. For this reason it is important not to hydrophobe the visible sides of dams but confine this treatment to the water channel only. Water retention achieved through the addition of acrylics may result in uncontrolled growth.

5.4.2. Informing the public

Sound conservation treatments, regardless of how well they conform to modern international practice may in some circumstances be seen as inappropriate for various reasons. Inaction will be considered neglect and responsive action seen as too heavy handed to some sectors. The care of objects requires communication with those who feel that the property belongs partly to them. Professional interests may also demand recognition of ownership. There are no religious ownership issues at these sites but there appears to be a continuum of scrutiny from some who feel that no matter what is done it could be done better, or sooner, or should have consulted them. Such critics tend to focus on one issue, which in itself may be a credible point, but one that ignores the overall balance of requirements. Others use criticism of one aspect to achieve their agenda on another point. Examples include discussions of environmental conditions inside a screened site to argue for their removal when the motivation for this is in fact based on a desire to have the site in a less disturbed aesthetic condition. Criticism requires a degree of honesty that allows a clear discussion of the issue so that a return to natural conditions is argued rather than that of environmental change.

It is important that the custodian body, the Office, informs the public of their role and the actions taken. This may be in the form of occasional newspaper articles and through information presented at the sites. It is important to engage the public in the management process so that all those who feel connected to the object can participate in its care. Cages and protective screens may be built to protect the site but the visitor will immediately feel excluded. A sign to explain why the exclusion is necessary and how the visitor can be included in protecting the site will always reduce adverse impacts

5.4.3. Monitoring of treatments

It is important to understand that all of the treatments implemented have a finite life. What the lifespan is can only be determined through time, although it is mentioned in the site records for Po Toi that a 2007 siloxane treatment was already due for renewal by 2008. In this case of an unexpectedly short durability it is important to begin applying the siloxane at the dilutions recommended above, as it appears that the undiluted siloxane is too viscous to penetrate and therefore unable to achieve a more three dimensional and protected placement. On the other hand the same undiluted siloxane has been applied to other surfaces, most notably at Joss House Bay in 2006, and is still performing well, albeit with biological regrowth beginning to obscure the surface again. Properly applied siloxane can be expected to remain effective for 8-15 years but whether an undiluted application can achieve the same durability remains to be seen. The evidence gleaned from the study sites suggests that the undiluted product is not performing all that well. Biocides are exhausted when plants reappear however it is better to undertake more detailed assessments of the ethyl silicate and siloxane treatments to ensure that incremental failure is monitored rather than relying on visible change.

Ethyl silicate consolidation

Consolidation has been carried out at Lung Ha Wan and is recommended for friable parts of Cheung Chau. Consolidation with ethyl silicate is not a straight forward process in that some stone types require much more treatment than others. Clay rich rocks, and this may also apply to fine glassy matrix rocks such as the volcanics in this study group, do not consolidate as readily as quartzitic sandstones. For silicate rich rocks a system of consolidation has been evolved by the author that applies 4-5 applications over a period of two working days. This level of saturation should provide adequate consolidant to effect a sound consolidation but requires assessment at the fourth application to determine whether the fifth is necessary. A recent treatment of this type worked well on all but a replacement section of a monument that had a more clay rich replacement section. This section remained friable after five applications but responded well to a further 2 pass consolidation 8 weeks after the first. On longer projects where treatment can be reviewed over years it has been found that stones can be consolidated 3-4 times in as many years before they become fully stable. This is clearly the approach available for the study sites and

thus regular assessments of the consolidated surface should be undertaken. Equally it is clear that a treatment is completed only when the surface has achieved the desired cohesion and viewing this as a staged and ongoing process is far more responsible and effective than a one off application that may not be absolutely convincing as a final treatment.

Annual inspections should be made of all consolidated rock to monitor change and to confirm that the treated surface has reached the desired cohesion. In one such monitoring program in Melbourne Australia a stone monument began to display evidence of very slight decohesion 16 years after first consolidation. This was not severe enough to warrant re-application but indicated the general longevity of treatment for that particular stone type.

Siloxane water repellency

Water repellency can be simply measured by measuring how much water is absorbed into a surface. The traditional method of doing this relies on a “Karsten tube” that feeds water into the surface at a measurable rate. This system might work well for masonry walls for which it was developed but is almost impossible to attach to a natural rock surface without leakage. A simpler more direct method has been developed by the author for measurement on rock surfaces. This method relies on surface spread and can be measured or photographed to give meaningful comparative results. The key to accuracy is in the ability to deliver a precisely reproducible quantity of water to the surface. This is achieved through the use of a plastic graduated column with two precision valves attached. One valve sets the drip rate and the other operates as the on off valve. A moderately priced apparatus should provide very regulated drip rates as low as one drop per second. The rate doesn’t matter as long as it is reproducible and the drips delivered are the same size . The dosage can be controlled either by the number of drops applied or the time interval delivering consistent drop rates. The attached syringe needle gauge also determines how large and consistent drop sizes are. The drop count method is easier to regulate but requires that the delivery tube, the syringe needle, be held far enough from the surface to develop to a consistent size. Typically 10 or 20 drops might be considered a suitable delivery volume to produce a measurable water streak.



Figure 4 Comparison of streak patterns on the siloxane treated inscription face and the rear of a sandstone headstone on the Isle of the Dead, Port Arthur, Tasmania, Australia. There is a noticeable difference in spread even though on this occasion the water delivery was not consistent with greater amounts applied to the rear. No matter how much water is applied the streak width should remain more or less the same. (Photograph by the author and in the collection of the Port Arthur Historic Site.

As the water runs down the surface it will be absorbed into the surface at a rate indicative of surface porosity. The resultant streak is photographed and measured both in maximum width and length. The location should be recorded for repeat testing.

It is advised that this system be used on a regular basis as soon as water repellency treatment is contemplated. The water should be applied and measured prior to treatment and then at every inspection time afterwards. It is only when the streak has returned to something resembling the pre-treatment pattern that re-treatment should be considered. The method is quick and non interventive.

Monitoring will determine not only the frequency of retreatment but also whether the treatment is at all effective and durable. The site records for Po Toi indicate that siloxane was applied in 2007 and that by 2008 there was already a consideration for retreatment. This site showed evidence of scaly siloxane deposits within cavities and thus the first requirement is to adjust the siloxane to a 15-20% dilution and have this applied in future. Once this adjusted solution has been applied its performance needs to be monitored. Failure after 1-3 years indicates a poor result whereas durability for 8 years and longer should be expected for a properly applied treatment.

5.4.4. More detailed studies

Salt contamination

The survey method adopted has been tailored to the available time at each site and relied on visual inspection and broad observations. This is a standard approach to surveying with the main purpose to identify issues rather than map exact deterioration extent. Of the sites inspected it is possibly only the saline deterioration evident at Cheung Chau that warrants further detailed study of salt erosion. It is recommended that spatial salt analysis be undertaken at this site to fully understand firstly whether salts are the cause of visual disturbance in the upper shelves, and then to study distribution to determine whether the garden beds above are indeed the source of saline water as appears to be the case. Various instruments are capable of measuring conductivity of absorbed salt and this provides very useful relative distribution maps. Mapping salt distribution is the most effective means of locating sources and is non-destructive, unlike the more traditional core drilling. Core drilling reveals the distribution of salt with depth but in the case of Cheung Chau if salts are present they will have flowed into the site across the surface and will not be deeply located. Even salty rocks that have accumulated surface deposits from within their matrix contain the highest levels in the outer 3 mm. Typically salt moves to the outer evaporation face and then may retain a secondary concentration peak at around 2-4 mm depth. The surface conductivity readings sample the outer surface only and may not extract salt from the secondary zone.

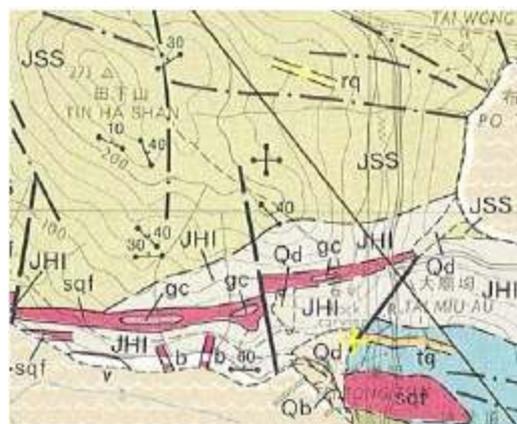
Geological classification

Surface inspection of the engraved boulder at Joss House Bay revealed a rock resembling granite but with what appeared to be phenocrysts of basalt embedded in boulders up to 200 mm in diameter. The geological map of this area indicates a coarse granite band (gc) running across the top of the site and this would seem to be the source rather than the various predominating volcanics forming the hill slope.

The visual observations are based on a limited view of a heavily weathered surface but the basalt inclusions are clearly evident. The angular matrix that appears granite like may however be a breccia or the described Eutaxite (JSS) that has encapsulated basalt fragments during formation.

Figure 5 Detail of the geology surrounding the engraved panel at Joss House Bay.

What is clear however is that visual inspection by a non specialist is not very informative and that there is a need to have the rocks accurately classified. The type of rock influences its ability to absorb consolidants and water proofing treatments, and better explains some surface alterations. It would be most beneficial to have a geologist identify the rocks type at each site and prepare fully interpreted thin sections to be kept in the site files.



6. Management Issues

6.1. Protection

All of the sites have received some form of protection, partially to keep the public away from fragile surfaces and also to deflect rain or otherwise modify the impact of rain and surf. The only exception to this is Wong Chuk Hang. Overall the site infrastructure is very heavy and is clearly an inheritance from previous management authorities. The approach to most sites involves a concrete path or stairs and at the end of this is an engraved panel contained by a glass screen or cage. Ideally an ancient outdoor site should retain its original setting or spatial context and thus any introduced infrastructure is an immediate compromise to this context. Allowing visitors to a site immediately necessitates some form of protection but this is not solely achieved through physical barriers. At least two of the sites, Kau Sai Chau and Lung Ha Wan, are only recognizable because they are contained within a barrier. In these cases it could be argued that the protective barriers draw visitors to the sites and the fact that they then exclude contact may incite vandalism. The two sites mentioned do not in themselves provide a great viewing experience and this has been known to incite negative impact at sites in Australia, where visitors are offered a long walk to a site with little visual interest. Visual interest in this context is not academic or educated interest but that required to stimulate the casual tourist.

Po Toi presents an interesting opportunity to study the benefits of screens due to the fact that one of the panels has had its screen badly damaged and temporarily removed. This now leaves one panel fully screened and the other protected only by a chain fence. It would be a worthwhile study to see to what extent the chained panel is more heavily impacted than the fully protected panel. Both panels have received the siloxane water repellent treatment and this alone is sufficient to protect the surfaces from any environmental impacts normally provided by the screens.

Previous sections have assessed the merits of full and partial screening and in general it can be said that screens will not provide a great deal of protection from salt damage. Dissolution of minerals through flowing water will have a greater impact and this can be fully addressed through the current methods of water diversion and water repellency.

6.2. Access

Access to most sites is through a long series of pathways or steps, all of which have been formed through the massive introduction of Portland cement concrete. It is clear that much of this has been in place for several decades. The concrete is generally very heavy and more than any other alteration to the sites, this has had the strongest impact.

Figure 6 Concrete steps at Cheung Chau with evidence of white salt and black enhanced biological growth due to the concrete.



It has also been pointed out in earlier sections that Portland cement concrete releases large amounts of soluble and semi soluble salts that can be very damaging to any rock they flow over. While there is little evidence of this practice continuing in recent years it is recommended that all future management aims to reduce and remove concrete from the sites.

The issue of access and protection raises another option. Rather than placing a physical barrier between the visitor and the engraving, which in the case of screens makes viewing of the surface quite difficult, it is proposed that future access be provided through suspended boardwalks that keep the visitor far enough from the surface to prevent touching.

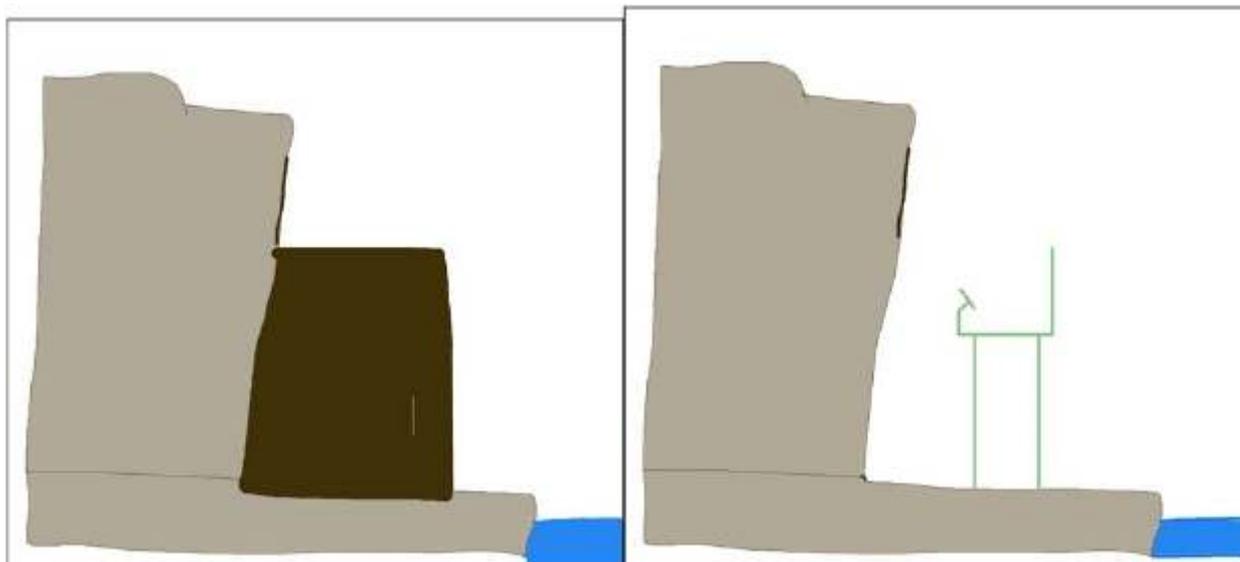


Figure 7 Schematic showing that instead of a solid concrete structure (left) pressing heavily up against the rock surface, a lightweight boardwalk can be lower and away far enough to create a barrier preventing access from all directions.

This approach could be applied effectively to most sites and would be particularly effective at those sited right on the cliffs. Po Toi lends itself to this approach as does Tung Lung where the use of concrete is particularly heavy and detracting. If the current concrete viewing platform were removed from Tung Lung and a light weight substitute installed there would be a substantial void between the platform and the engraved panel that would make reaching the panel difficult for the natural ground level.

Typhoon impact on lighter structures may require them to be stronger than normal, however it is believed that a well designed light weight structure should be able to withstand gale force winds if designed for such stress.

6.3. Interpretation and signage

Each site has interpretative signage installed near to the engraved panel. These give some of the known information about meaning, when the engravings may have been done and advice on the role played by the Antiquities and Monuments Ordinance in protecting the site. There is no negative message about damage or behaviour which ensures that visitors feel welcome. There is some information not included at some sites that visitors may find interesting such as who made the work and how they lived their lives. Additional information about the geological setting and perhaps social history of the area may be found to engage visitors and make their visit more worthwhile.

While signage at the panel is generally informative and adequate, that signposting the site from off main thoroughfares is less informative. Signs to direct vehicular traffic should do that and no more, whereas signs off walking paths, particularly where these look down onto the site or the coastline, as at Po Toi, could begin to tell some of the general background information. This approach to giving general information about the area and its people can be very effective in offsetting some of the dampened enthusiasm at sites like Lung Ha Wan, where the panel itself is perhaps only as engaging as the surrounding rocks or the view out to sea and along the coast. In Australia the trend has been to expand the visitors experience by describing much more of the social and geographical context in which a site exists, pointing out food sources and other features of the local landscape. This is an effective means of diffusing expectations when the visitor arrives after several hours to a site that might otherwise offer minimal visual stimulus for the non professional visitor. The geological data recommended in this report would make an interesting interpretation in itself and expand the interest currently being generated from the newly created geological park near to some of the sites.

6.4. Tourism value

Nine sites have been located around the Hong Kong shores and islands. It is understood that there is some obligation to make these sites known and accessible to the local public and to encourage tourism.

Tourism is not an area of expertise for this writer but observations of tourist behaviour and particularly expectations and daily thresholds leads to the view that tourism requirements can be satisfied with only a few sites and not by all nine. It is better to encourage visitation to 2-4 highly managed and visually diverse sites rather than installing obligatory access to all. Two sites have been mentioned already that offer difficult to read surfaces. Visitors to these sites will not feel as rewarded as they might at Po Toi, Joss House Bay and Tung Lung, among others. Tourism is a curious beast that needs to satisfy several requirements. The journey to the site, opportunities to go on to other activities including dining, and to connect to further knowledge that may be found in a museum or other place all lead to a satisfying experience. This is exactly the experience provided at Po Toi where the visit combines a boat ride, site visit and restaurant meal all to very good standard. A similar experience can be had at Joss House Bay and Cheung Chau whereas Kau Sau Chau offers very little in each of these categories. Kau Sau Chau is an example of where the protective grille is about the only means by which the casual visitor can find the site and there is little likelihood of vandalism if the cage were removed and the site not promoted.

It is recommended that the use of sites for tourism be specifically designed for that purpose and that sites not forming part of tours be downgraded in terms of infrastructure. At Lung Ha Wan this downgrading may simply be through the removal of the track and platform immediately adjacent to the panel and emphasizing access to the cliffs for fishing. The site can still be found by walking further around the cliff and may be indicated with a simple discreet marker. This may present dangers the management authority will not wish to be held responsible for but the pathway is currently used by fisherman taking greater risks than visitors to the engraved panel do.

A day tour to study rock engravings requires access to no more than three sites. These three should be chosen based on the overall visitor experience as described previously. Once agreed upon these sites should be brought into exemplary site condition through the removal of heavy infrastructure and substitution with boardwalks that tread lightly on the site and provide physical separation without screening. A trip starting from Big Wave Bay and taking in Po Toi for lunch and then on to Tung Lung Island would be a rich introduction to the sites. Directions to Wong Chuk Hang with a ferry schedule to Cheung Chau may also then stimulate self directed tours the following day for those wishing to learn more about the sites. The Joss House Bay site may also be considered as it offers both an engraving and temple experience with an excellent restaurant in the vicinity. All of these sites can be accessed by sea and this in itself provides controls over unsupervised access.

Of the remaining sites it is recommended that these not be promoted for mass tourism but left for local visitors. It is quite important that any tourism development be carried out in conjunction with a tourism operator who understands the needs of tourists so that these can be balanced with the protective and interpretative requirements.

7. Future maintenance.

It is quite clear that the responsible agency has dedicated annual funds to the ongoing care of these sites. It is most important that the sites be regularly inspected to assess both the condition and performance of stabilization treatments. There is no need to increase current input as the sites are on the whole quite stable.

The main emphasis should be on managing visitors, mainly through identifying needs and accommodating these within an overall preservation program. Tourism does not necessarily lead to damage but does require infrastructure that otherwise detracts from the natural setting. The emphasis in future infrastructure upgrades should be away from screens and barriers and move towards physical separation through separating boardwalks. This approach is the ideal arrangement at sites such as Po Toi

and Tung Lung but more difficult to achieve at Shek Pik, Cheung Chau, and Joss House Bay. Kau Sau Chau could have all infrastructure removed without fear of damage from visitors as could Lung Ha Wan. This latter site could equally be protected through an isolated boardwalk rather than the current very reflective screen and concrete viewing stage.

Maintenance should also focus on removing all Portland cement dams directly above engraved panels and substituting these with siliceous grout dams, as described in earlier sections.

Siloxane treatments need to be monitored annually and replenished when they show signs of exhaustion. This will be determined through mapping of the water streak, as discussed.

8. Site surveys

This section presents the field notes compiled during the inspections. They have been edited and further expanded to provide detailed observation at each site. The data have been recorded into a handheld database containing fields relevant to a wide range of sites and not specifically those relating to the nine Hong Kong sites. The handheld database has been transported to MS Access and then presented here in report form.

8.1. Big Wave Bay

Site name	Big Wave Bay
Subsite name	
Title type	Government Land
State	Hong Kong
Painting or Engraving	Engraving
Description, brief	Engraved geometric forms on vertical face of exposed block in cluster of similarly compact blocks.



Rock type general Refer to geological map. Difficult to assess visually but nearby rocks are of the dense white flecked diorite appearance, with a thick yellow outer crust. Other rocks of similar surface colour are homogenous throughout and more like tuff. The geological map indicates this location to be a breccia tuff and its angular constituents agree with this classification.

Morphology	Exposed angular block within a series of benches emerging out of hill slope.
Visit dates	07 11 2009, 01:49
Survey team	Andrew Thorn, Eddy, Hong, Karen
Photographic record	Pentax digital SLR 6Mp
Best photo time	



Shade all day due to shelter. Morning and evening will have strong cast shadows from cage.

Support surface length	2.000
Engraved area length	1.800
Engraved area height	1.100
Dripline distance	0
Height at dripline	-
Existing documents	Site records kept by Office.

Subjects Geometric patterns.

Date -

Dating method -

Dating potential -

Solar window coordinates 133-267 facing south. Direct insolation reduced by current roof. Late afternoon sun will enter but at an acute angle with minimal heating.

Vegetal shade value

No shade from trees. Sun will shine directly on carving if the current shelter were removed.

Surface slope 80-85°, sloping backwards slightly.

Floor type Rocky benches.

Terrain below site Steep exposed rock benches down to wider platforms nearer sea level.

Terrain above site Steep soil covered hill slope rising 4 metres up to the north. This slope will deliver moderate quantities of mineral rich water to the rear of the carved panel. This has been intercepted with a series of diversion drains.

Moisture survey No measurements taken but there would normally be some surface wash, which has now been diverted. Seepage is a greater threat and wet patches, one of which is seen at right associated with fine fissures in the rock, are evident in lower areas. If these areas are found to have higher moisture levels then the water diversion system needs to be modified to prevent such infiltration. This may not be readily rectified as the seepage may come from much further into the hill slope above. There are no signs of erosion associated with this apparent seepage and more often the seepage waters have become enriched with consolidating minerals and can remain more durable than their surroundings.



Salts distribution Not measured and no visual evidence of damaging salts. This site, like many others has substantial concrete infrastructure. Dam walls and cage supports can all contribute to salt deposition. Roof and dam prevent washing of surface so potential for accumulation of aerosols.

Water wash damage Water will wash down from the 4 metre vegetated cliff above. The current dam will not intercept all of this as much will travel into and through the block system below the surface.

Rock stability The rock appears moderately stable but there is some degree of friability in the outer altered surface. Ethyl silicate consolidation would improve cohesion in the outer surface but the problem is not severe enough to make this an immediate recommendation. In general consolidation with ethyl silicate is beneficial and will give the surface more durability and abrasion resistance.

Ground erosion There is no visible impact from ground water immediately below the engraved panel.

Surface alterations The cultural surface has orange yellow mineralization over a white flecked dark rock. At the east end the engraved channels are darker than surroundings whereas for the majority they are substantially lighter. The lighter engraving channels may be remnant chalking and has similar appearance to the more obvious remnants at Tung Lung.

Dust accumulation No dust impacting on the carved areas.

Fire risk Too far from plants to be an issue.

Weeds No weeds encroach into the site.

Biological activity Minor lichens present but generally not at damaging levels. No need for intervention unless they begin to obscure the surface.

Animal impact	No visible impact from animals.
Bird impact	No evidence of birds near engravings.
Insect impact	No impact from insects.
Human impact	No graffiti or other impacts.

Further research Study the moisture distribution associated with seepage staining to determine whether there is in fact water seeping into the engraved panel from within the formation.

Management issues

This site has received the same degree of heavy infrastructure as most other sites. Access path, steps and roof fixing points are all in Portland cement material. The appearance is one of heaviness and the potential impact from concrete above the engravings is high. It has been recommended throughout this report that there needs to be a move away from concrete towards more light weight access. Equally the use of Portland cement for building water diversion dams and other features above the engravings should be avoided. Dams can be constructed from siliceous grout materials as described within this report.



It is difficult to modify the protective structure due to its location close to a busy recreational area. Visitors to this site will not be motivated solely to view the engravings and this can lead to adverse impacts. It is therefore recommended that the current level of protection remain in place.

Previous Treatments 2008 Cleaned with surfactant

Summary of Conditions

Overall the engraved panel appears stable despite the visual impression of water seepage through fissures within the panel. There is a heavy presence of Portland cement however none of this appears to have impacted on the surface of the rock within the shelter. The surface gives the impression of being slightly granular and would become more cohesive with ethyl silicate consolidation. This is not warranted at this point but may be considered as an elective treatment to provide greater durability.

While the grille is a strongly visible barrier there is little alternative to lighten this due to it being very close to recreational areas. Visitors along the path leading to the site will not all have chosen to view the engravings and in this situation there can be adverse impacts through disinterest.

Proposed action

Remove Portland cement in time and replace diversion dams with siliceous grout based walls.

Priority for action

Short to medium term action.

8.2. Cheung Chau

Site name	Cheung Chau
Subsite name	
Title type	Private Land
State	Hong Kong



Rock type general Has the visual appearance of a granular and moderately porous tuff or similar volcanic flow. According to the geological map however it is located with an isolated granite formation. The engraved panel does not have the appearance of granite and may be an isolated remnant of a volcanic.

Morphology Exposed semi-angular series of blocks emerging out of hill slope.

Painting or Engraving Engraving

Description, brief Engraved geometric forms on vertical faces of exposed blocks in cluster of similarly compact blocks.



Visit dates 08 11 2009, 02:17

Survey team Andrew Thorn, Hong, Andy

Photographic record Pentax digital SLR 6Mp

Best photo time Shade all afternoon, full sun in mid morning and variable shade in early morning

Support surface 4.000

length 2.500

Engraved area length 1.100

Engraved area height Fully exposed but now sheltered by screen.

Dripline distance -

Height at dripline reports

Existing documents Geometric patterns.

Subjects -

Date -

Dating method -

Dating potential

Solar window coordinates 002-185 facing east.

002 00 90

030 00 90

060 00 90

090 04 90

120 21 90

150 31 90

185 38 90 trees 45° here

Vegetal shade value Slight shade from trees to the east. Hill slope and trees to the south screen afternoon sun.

Surface slope 80-85°

Floor type Unknown due to pavement development.

Terrain below site Can no longer be discerned but assumed to be steep exposed rock benches down to sea level.

Terrain above site Gently sloping soil covered hill rising 50 metres up to the north. Will deliver moderate quantities of mineral rich water to the rear of the carved panel, although the hotel building and drainage systems intercept much of this. A garden bed immediately above the site appears to be the source of some water flow that is currently impacting on the site.

Moisture survey No measurements taken but there would normally be some surface wash before the current shelter was built. Seepage is a greater threat particularly due to the presence of a fertilized and watered garden bed a few metres above the site. There is currently no visible seepage but drainage from the garden may all be subsurface. The site itself has evidence of water flow both within the carved panels and more severely on an exposed surface higher up within the enclosure. A more comprehensive study of moisture is required here.

Salts distribution Not measured but salts suspected of playing a substantial role in erosion in parts of this site. Eroded grains can be found beneath upper eroding blocks. Sources of salt include evident fertilizing of the garden bed and visible presence of concrete in the retaining walls.

Water wash damage Water wash has been removed by present structure. Seepage is more significant in both erosion impact and biological staining.

Rock stability Rock appears moderately stable but there is some degree of friability in the surface. While there is no direct evidence without further study, it is likely that mineral rich seepage is actively impacting on the surface.

Ground erosion There is no visible impact from the ground although biological seepage stains occur close to the current artificial floor level.

Surface alterations Cultural surface has slight yellow mineralization over a yellow rock colour.

Dust accumulation No dust impacting on the carved areas.

Fire risk Too far from plants to be an issue. The glass enclosure should protect against fire and the lush vegetation will not burn vigorously.

Weeds No weeds encroach into the site although plants from adjacent slope grow into the cage.

Biological activity Minor spread of grey crustose lichens at west end but green and black algal staining apparent in many places. These all relate to seepage which is clear from their condition, to be ongoing.

Animal impact No visible impact from animals.

Bird impact No evidence of birds near engravings.

Insect impact No impact from insects.

Human impact Green paint applied to east panel. This is not highlighting as it covers the channels and background outer surface equally. Portland cement has been used abundantly to cap several of the blocks. It is doubtful that this material is providing any benefit to stability and should all be removed. This material appears to predate the glass enclosure and is friable and broken. It has very poor adhesion to the rock which is caused by the fact that salts released by such cement cause disruption to rocks. This usually results in a



separation between the two surfaces as seen here.

Further research **Moisture and salt survey** is recommended to map the presence and distribution of water and soluble salt. Mapping will help trace the cause and source.

Data logging of moisture may allow a clearer understanding of moisture entry if it is not immediately apparent from a one off survey.

Salt analysis, once presence confirmed, will help understand the damaging mechanism. It is enough generally however to identify a salt through its conductivity property and to then extract it from the rock without the need to know exactly which species is present.



Management issues

Garden – Hotel owner needs to be informed of impact from garden once this has been identified as a contributory impact. The Government should work with the Hotel to rectify the problem to avoid generating negative feelings towards the engraved site from commercial interests. Concrete dam and fixings.

Access path contains concrete steps. These are not seen to be impacting but are releasing large quantities of salt as seen in Figure 6.

Previous Treatments No treatments applied in recent times.

Summary of Conditions

This site appears less stable than all others due largely to the seepage from above. There is definite impact in the upper rock benches but none other than enhanced biological growth in the engraved panel. Old cement repairs are providing no stabilizing benefit and should be removed immediately.

Proposed action

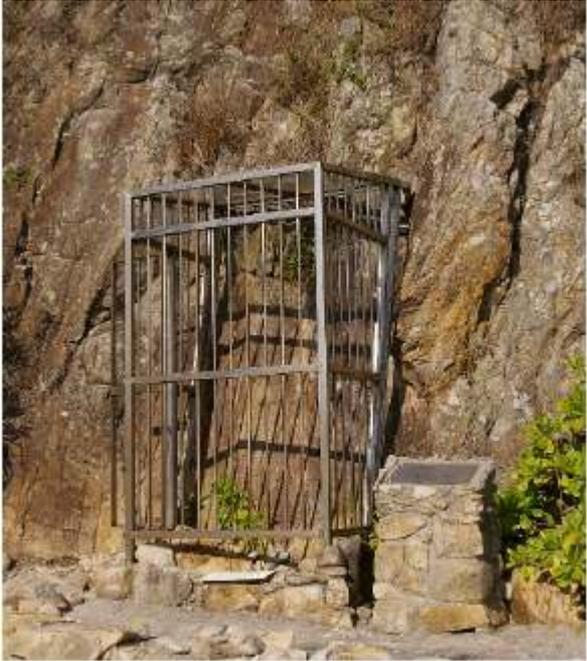
Subject to findings- desalinate and consolidate the salt affected area.

Remove all cement cappings for within the enclosure as these appear to no longer contribute to keeping water out of the rock.

Do not hydrophobe this surface until the water seepage problem is under control. There should be no reason to carry out this treatment due to the enclosure. It is recommended that the enclosure remain due to high visitor traffic in the vicinity of the site.

Priority for action 1
Treatments

8.3. *Kau Sai Chau*

Site name	Kau Sai Chau	
Subsite name		
Title type	Government Land	
State	Hong Kong	
Painting or Engraving	Engraving	
Support surface length	2.800	
Engraved area length	1.000	
Engraved area height	1.800	
Dripline distance	0	
Height at dripline	-	
Existing documents	Site records held by client	
Subjects	Very indistinct.	
Date	-	
Dating method	-	
Dating potential	-	
Solar window coordinates	94-244, facing NW	
Vegetal shade value	No shade other than rock itself.	
Surface slope	90°	
Floor type	Covered by concrete but assumed to be exposed blocks down to sea.	
Terrain below site	Steep rocky benches down to sea 5 metres below.	
Terrain above site	Exposed blocks giving way higher up to soil covered rocky hillside.	
Rock type general	Igneous or metamorphic dense rock. Geological map indicates Fine ash Tuff (JHI)	
Morphology	Exposed block out of hill slope.	
Description, brief	Very faint engraving on slightly undulating surface on lower short cliff face. Inclined back at around 70-80°.	
Visit dates	05 11 2009, 05:56	
Survey team	Andrew Thorn, Hong, Karen	
Photographic record	Pentax digital SLR 6Mp	
Best photo time	Early morning would provide raking light relief to best capture details. Afternoon sun not reaching sufficient angle to highlight relief.	
Moisture survey	No measurements taken but evidence of seepage onto right hand side of panel from fissure just above carved panel. Surface water will wash down surface from cliff above.	
Salts distribution	Not measured and no visual evidence of damaging salts.	
Water wash damage	Water will wash down from the 6-8 metre vegetated cliff above. High water wash expected due to exposed hill slope.	
Rock stability	Rock appears generally stable with no threat to carved panel.	
Ground erosion	No evidence of erosion from the ground. A horizontal fissure below isolates the	

carved panel from lower ground water influences.

Surface alterations Cultural surface has red brown mineralization over a yellow tan rock. None of this is detrimental or destabilizing.

Dust accumulation No dust impacting on the carved areas.

Fire risk Too far from plants to be an issue.

Weeds No weeds encroach into the site however plants growing at the base need to be controlled to avoid abrasion when bigger. Earlier photographs held by client indicate substantial vegetation around engraved panel in previous years.

Biological activity Some of the surface staining is no doubt biological.



Animal impact No visible impact from animals.

Bird impact No evidence of birds near engravings.

Insect impact No insect impacts.

Human impact No graffiti or other impacts directly on the panel or its surrounds. There is a simple inscription on the adjacent rock cliff but this does not appear to be an aggressive vandalistic inscription.

Further research

Management issues

This site is dominated by the installation of a cage and signage cairn. Without these two features the site would not be readily discoverable by visitors. It is difficult to access the site other than directly from the sea and the current infrastructure acts as a navigation beacon for such visits. The panel itself is quite subtle to read and would not provide a rewarding experience other than for those intent on studying all engravings in the region.

It is recommended that all infrastructure be removed from this site as it will act as a motive for impact as much as preventing it. Casual visits to the site should not be encouraged and it is believed that its visual obscurity is enough protection. The site has been recorded and its protection should continue but only to the extent of keeping vegetation from the surface and removing graffiti should this occur. There is a painted inscription on nearby rocks but this is not an act of vandalism.

Previous Treatments Removal of plants.

Summary of Conditions

This site appears very stable with only the potential threat from seepage and wash from the supporting hill slope identified as an issue. The greater threat comes from the site being locatable from the sea as presenting a site with a protective cage will often provoke adverse impact.

Proposed action Remove all infrastructure and reduce the signage to a discreet locally visible sign.

Priority for action 3

8.4. Lung Ha Wan

Site name	Lung Ha Wan
Subsite name	
Title type	Government Land
State	Hong Kong
Painting or Engraving	Engraving
Support surface length	1.500
Engraved area length	1.500
Engraved area height	1.300
Dripline distance	0
Height at dripline	1.500
Existing documents	reports
Subjects	too abstract.



Date	-
Dating method	-
Dating potential	-
Solar window coordinates	10-195
Vegetal shade value	No shade
Surface slope	85-90°
Floor type	rock slab
Terrain below site	

Steep rocky benches down to sea.

Terrain above site

Steep soil covered rocky hillside.



Rock type general Lava

Morphology Exposed block out of hill slope.

Description, brief Flat vertical surface facing SE on exposed durable lava. The geological map describes this as a Rhyolite lava, which makes this potentially a very durable rock.

Visit dates 03 11 2009, 06:52

Survey team Andrew Thorn, Eddy, Hong, Andy, Evita

Photographic record Pentax digital SLR 6Mp

Best photo time Late afternoon would provide raking light relief to best capture details.

Moisture survey No measurements taken but no evidence of water flowing through the stone.

Salts distribution Not measured and no visual evidence of damaging salts.

Water wash damage Water flows into the carved area from the outer rim.

Rock stability Rock appears generally stable with no threat to carved areas.

Ground erosion No evidence of erosion from the ground.

Surface alterations Cultural surface has a grey consolidated dust on the surface.

Dust accumulation Dust has been consolidated onto the surface. This appears to be through the

application of a siloxane treatment that has not absorbed well into the surface. Rhyolite is a very dense rock and would not absorb viscous siloxane readily. Future treatments require suitable dilution ratios to be determined.

Fire risk	Too far from plants to be an issue.
Weeds	No weeds encroach into the site.
Biological activity	No evidence of biota impacting the carvings.
Animal impact	No visible impact from animals.
Bird impact	No evidence of birds near engravings.
Insect impact	No insect impacts.
Human impact	No graffiti or other impacts.
Previous Treatments	2006 Brush cleaning, ethyl silicate consolidation, siloxane hydrophobic treatment
Further research	Assess water flow through rock.
Management issues	

The access path, viewing area and protective screen all throw up issues in relation to visitor experience at this site. The first point to make is that this site has been considered to be ambiguous in its origins. Some believe it to be natural while others are clear that it represents defined motifs. This writer is in no position to contribute to this issue. While the motifs may be indistinct it is very clear that the site does not present a rich cultural experience. The markings are not clear and this is made even more difficult by the highly reflective screen. The screen has been placed there for two reasons. The first is to prevent damage and the second to reduce salt spray and resultant damage. Given that the site is Rhyolite and already treated with siloxane there is little extra benefit achieved through a protective screen. Protection from the public is necessary but at this site, as at Kau Sai Chau, it is questionable whether presentation to the public is necessary. The current viewing platform is ill equipped to take more than 3-4 people and in itself quite precariously positioned. Access to the site is gained through Portland cement steps and further concrete has been used to support the viewing platform. This massive installation provides minimal visitor experience and it is proposed that this site be reduced to a recorded site with no infrastructure. It is recommended that the track be terminated at the point where it branches down to the pathway used by fishermen gaining access to nearby shoreline rock platforms. Visits to the site can be achieved from this location and the removal of all infrastructure will still permit viewing at a greater distance from the rock. If necessary, determined by the Office's legal responsibilities to protect visitors to their sites, it would be possible to construct a light weight platform in the rock ledges below the site at the level where Hong stands in the adjacent photo.



Summary of Conditions

This site appears to be very stable, which is to be expected of a Rhyolitic rock. The main issues here relate to presentation. The current screen obscures the viewing conditions and the viewing platform is too small for more than a few people at a time. The images have not been confirmed absolutely to be cultural markings and for this and the weight of the infrastructure it is recommended that the site be downgraded to a registered site with no infrastructure requirement.

Recent treatments are evident on close inspection, resulting from a viscous treatment applied to a dense rock. Future siloxane treatment should refer to the sections above outlining dilution ratios. The next siloxane treatment applied to any of the nine sites should be in the order of a 20% dilution.

8.5. Po Toi

Site name	Po Toi
Subsite name	Po Toi 1 (Left side, screened panel)
Title type	Government Land
State	Hong Kong
Painting or Engraving	Engraving
Support surface length	1.600



Engraved area length	1.400
Engraved area height	2.000
Dripline distance	0
Height at dripline	2.500
Existing documents	reports
Subjects	Geometric patterns
Date	-
Dating method	-
Dating potential	-

Solar window coordinates Faces SE

Vegetal shade value No shade

Surface slope 85-90°

Floor type Covered with concrete but assumed to be rock platform of very narrow dimensions.

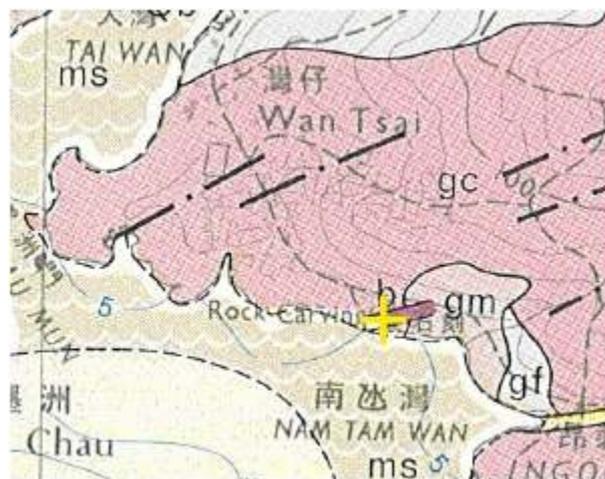
Terrain below site Steep rocky benches down to sea.

Terrain above site Exposed blocks giving way to steep soil covered rocky hillside.

Rock type general Metamorphosed arkose (Geological map describes this area as basalt) or similar seam approximately 20 metres wide between two seams of granite. There appears to be an altered zone immediately touching each granite formation, suggesting that the arkose (basalt) was there first and altered by the granite intrusion.

Morphology Exposed block out of hill slope.

Description, brief Geometric panel on vertical face of block facing SE.



Visit dates 4 11 2009
Survey team Andrew Thorn, Hong, Eddy Leung, Karen Fong.
Photographic record Pentax digital SLR 6Mp
Best photo time Raking light in early morning and late afternoon would highlight these engravings best. Otherwise in full sun all day.

Moisture survey No moisture measurements taken but wash can run off from above. This has been diverted to some extent by the building of Portland cement dam walls that have failed from time to time. No evidence of seepage through the surface. Drainage core drillings onto the rock slope show signs of minor drainage but it is questionable whether these are performing any protective role. There is no sign of rock bursting from the surface due to hydraulic pressure and this appears to be a theoretical response to a perceived rather than real problem.

There is evidence of salt staining at PO Toi 2 from dam wall failure. It is recommended that future dam walling be built from siliceous grout materials, either lithium or ethyl silicate based, to avoid such potential damage and disfigurement. It is further recommended that the current dam walls and cappings be removed in the short term and that siliceous grout substitutes be built. This will serve as a useful monitored assessment of the ability of siliceous grouts to divert water in this manner.

Salts distribution Not measured and no visual evidence of damaging salts.

Water wash damage Water washing into the carved surface has the potential to cause delaminations by entering into the upper opening of several detachments. A very large one of these is found in the upper right corner. This detachment has been capped but the filling has cracked away ensuring that water can enter. Water into these upper openings will lead to dissolution and detachment in several areas. This is quite a different mechanism to that referred to somewhat dismissively in relation to the core drilled drainage pipes. The pipes are drawing water from deep within the rock whereas these delaminations and associated water infiltration are surface phenomena.



Rock stability Through water entry described above there are several detaching areas that could further deteriorate and detach completely in time. One of these is quite large and while it has been capped with a Portland cement based grout this is not a satisfactory material and there is already a separation along one edge. The detachment is 250 mm across and possibly as far down the surface. This detachment requires additional attachment support to remain intact. This area does not contain engraved surfaces but should be retained as part of the significant surface.

Ground erosion The floor of this panel has been formed from concrete and there is a discernible granular erosion along the bottom edge, rising to 50 mm. This is clearly resulting from the damaging constituents of the concrete itself having the ability to constantly recrystallize as the drainage water dries out and re-wets.

Surface alterations This carving has a uniform light orange mineralisation that is no stronger on the un-carved upper surface than in the depths of the engraving. There is a grey residue in many crevices that is most likely residual siloxane that has been applied undiluted and thus more likely to form a visible residue. Siloxane can be applied at more dilute concentrations with equal effectiveness and it is expected that basalt will not be highly absorbent to this viscous application.

Dust accumulation Dust not a problem on this vertical surface.

Fire risk Minimal fire risk at this site due to a lack of vegetation and proximity to the sea.

Weeds No weeds encroach into the site.

Biological activity

There may be some staining from biological growth but this is not disfiguring to the engravings.

Animal impact No visible impact from animals.

Bird impact No evidence of birds near engravings.

Insect impact No insect impacts.

Human impact No evident vandalism.

The screen has been severely damaged and this has scratched the surface. Such scratches can be disguised using pigments in ethyl silicate.

Some barely discernible green paint splatters can be seen here and there that have come from painting of the enclosure. All sites must be fully protected if further painting works are to be undertaken.

Further research

Previous Treatments Surfactant clean 2004,2007,2009 Biota suppressant 2007 Siloxane hydrophobe 2007

Management issues

Earlier sections have discussed the heaviness of this and several other sites in terms of infrastructure. There is far too much concrete present here and at this site damage is evident that can be directly ascribed to the concrete. The damage is minor but indicates the unsuitability of this material. In other sections it has been argued that screens provide modifications to the environmental impacts but they cannot be weighed up as necessarily good or bad for the engraved panels. Much of the protective function is equally accommodated by water repellent applications such as the siloxane currently being employed. The difference in protection for the two Po Toi panels will provide an interesting comparison of human impact and it is predicted that there will be no greater impact at the chained panel, compared to the screened panel.

Given that the screen provides minimal improvement against environmental impact but makes viewing of the otherwise clear and interesting panels it is recommended that an alternative approach be considered.

Separation of the panel from the visitor is considered a sound principle and the most effective site protection is that at Wong Chuk Hang where the viewing platform is separated from the engraved panels but does not encroach onto the immediate site in any substantial way. The design of the WCH platform should not be taken as a prototype and any further platform designs should aim to be light both in mass and visual impact.

It is recommended that in time all concrete infrastructure (all that visible in the adjacent photograph) be removed from the visually defined setting. No concrete should be visible from the site. In its place a light weight metal boardwalk could be constructed that stays at least 1.5 metres from the surfaces. Such a platform needs to be designed with typhoons in mind, but simple separation will be enough to prevent wilful damage.

Proposed action

Replacement of infrastructure as proposed.

Replacement of diversion dams and cappings with siliceous grout as described in previous sections.



Subsite name	Po Toi 2
Title type	Government Land
State	Hong Kong
Painting or Engraving	Engraving
Support surface length	2.000
Engraved area length	1.800
Engraved area height	1.400
Dripline distance	0
Height at dripline	1.500
Existing documents	reports
Subjects	Geometric patterns
Date	-
Dating method	-
Dating potential	-
Solar window coordinates	Faces SE
Vegetal shade value	No shade
Surface slope	85-90°
Floor type	



Covered with concrete but assumed to be rock platform of very narrow dimensions.

Terrain below site Steep rocky benches down to sea.

Terrain above site Exposed blocks giving way to steep soil covered rocky hillside.

Rock type general Metamorphosed arkose (basalt indicated on geo map) or similar seam approximately 20 metres wide between two seams of granite. There appears to be an altered zone immediately touching each granite formation, suggesting that the arkose/basalt was there first but has been altered by the granite intrusion.

Morphology Exposed block out of hill slope.

Description, brief Geometric panel on vertical face of block facing SE.

Visit dates 4 11 2009

Survey team Andrew Thorn, Hong, Eddy Leung, Karen Fong.

Photographic record Pentax digital SLR 6Mp

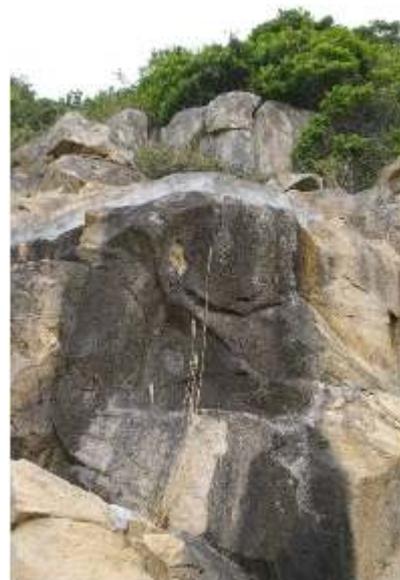
Best photo time Raking light in early morning and late afternoon would highlight these engravings best. Otherwise in full sun all day.

Moisture survey No moisture measurements taken but wash can run off from above. This has been diverted to some extent by the building of dam walls that fail from time to time. Slight evidence of seepage through the surface forming a grey salt pattern away from fissure. This salt is most likely gypsum or silica and is not disfiguring or over engraved surface.

Salts distribution Not measured and no visual evidence of damaging salts other than the seepage stains mentioned above.

Water wash damage Water washes down from the dam wall above and there is strong evidence of soluble salts being washed down with it, having been leached out of the concrete. The salts themselves have not reached the engraving and have not disrupted the rock surface where they do occur. Their most

significant impact is through the promotion of biological growth and this is quite pronounced through the engraved panels (adjacent photograph). Whether this has become significantly enhanced as a result of the salt wash is not certain but this can be determined from early photographs predating the dam walls. The SE exposure is not conducive to high biological growth. What is also clear from surveying the right hand panel is that there is no distinction between the previously caged sections and those that have always been exposed. There has been some comment about the dangers of creating biologically conducive conditions within enclosures such as the left hand panel. At Po Toi there is absolutely no evidence of this and no justification in pursuing this view.



Rock stability The rock is moderately stable with minimal evidence of detachment and no granular erosion or particle dislodgement.

Ground erosion The floor of this panel has been formed from concrete and there is no discernible granular erosion along the bottom edge. A tide mark has developed as a result of water catchment up against the rock but this is not friable.

Surface alterations This surface has a deep orange mineralisation in some un-carved areas that may be the original surface that was carved into. This orange level is 2-3 mm above the lighter surface surrounding the carved area. Some lighter orange surfaces can be found that are 0.5-1 mm above the carved surface.

Dust accumulation Dust not a problem on this vertical surface.

Paint stability Engraving

Fire risk Minimal fire risk at this site due to lack of vegetation and proximity to the sea.

Weeds No weeds encroach into the site.

Biological activity Black streaks down the engraving may have become enhanced by minerals leached from the concrete. This can be confirmed from photographs that predate the dam wall. Control of biota is better achieved by applying ethanol at prescribed intervals.

Animal impact No visible impact from animals.

Bird impact No evidence of birds near engravings.

Insect impact Two or three insect mud nests have been built on the surface away from carvings. These are believed to have been built in the last 3-4 months and may be a seasonal occurrence. They do not obscure the carving but increased colonization may become an issue.

Human impact No evident vandalism.

Further research

Previous Treatments Surfactant clean 2004,2007,2009 Biota suppressant 2007 Siloxane hydrophobe 2007

Management issues

The access issues have been described in full for the other panel. All recommendations will be applied to both panels equally.

8.6. Shek Pik

Site name	Shek Pik
Subsite name	
Title type	Government Land
State	Hong Kong
Painting or Engraving	Engraving
Support surface length	2.000
Engraved area length	0.800
Engraved area height	1.000
Dripline distance	0
Height at dripline	-
Existing documents	reports
Subjects	Geometric patterns.
Date	-
Dating method	-
Dating potential	-
Solar window coordinates	201-61, facing west



Vegetal shade value Light shade to the west. Sun will shine directly on shelter in afternoons.

Surface slope 80-85°

Floor type Currently large expanse of flat soil.

Terrain below site Gently sloping soil.

Terrain above site Steep soil covered hill slope rising 8-10 metres up to the east. Will deliver large quantities of mineral rich water to the site.

Rock type general Geological map indicates Rhyolite lava and tuff (JLT). The carved panel is a dense yellow fine grained rock with larger inclusions. This feature is consistent with it being a tuff or volcanic flow formation. Rhyolitic tuff will be denser and more durable.

Morphology Exposed series of small blocks out of hill slope. Only one of these is carved.

Description, brief

Engraved geometric forms on lower exposed block in cluster of similarly compact blocks.

Visit dates 06 11 2009, 01:28

Survey team Andrew Thorn, Eddy, Andy, William

Photographic record Pentax digital SLR 6Mp

Best photo time Shade all day until late afternoon sun strikes the surface full on.

Moisture survey No measurements taken but there will be high water flows during and after rain. Seepage may equally be significant through the rock if of volcanic origin. A series of almost vertical fissures located about 1 metre behind the carved panel intercept some surface water flow. Where this water then ends up is unknown but the inclination of these fissures suggests water will be directed away from the carved block and should not flow through to the carved surface.

Salts distribution Not measured and no visual evidence of damaging salts. Where concrete has been recently placed above the site there is evidence of salt runs in the upper dam wall running onto rocks below. Other streaks are concrete slurry runs. Concrete dams should be replaced with siliceous grout.

Water wash damage Water will wash down from the 8 -10 metre vegetated cliff above. High water wash expected but no evidence of impact on the carved panel itself. It is important to assess the ability of the dam to divert all water.

Rock stability Rock appears moderately stable but there is some degree of friability. Consolidation with ethyl silicate could be considered. Siloxane should not be applied to this site due to the high potential for internal moisture migration.

Ground erosion There is no visible impact from the ground, despite the carved block emerging from the soil.

Surface alterations Cultural surface has orange brown mineralization over a yellow tan rock.

Dust accumulation No dust impacting on the carved areas although there is general dust generating loose soil and debris in the vicinity.

Paint stability -

Fire risk Too far from plants to be an issue.

Weeds No weeds encroach into the site.

Biological activity Minor impact.

Animal impact No visible impact from animals.

Bird impact No evidence of birds near engravings.

Insect impact Two mud insect nests present within the carved area. These should be removed.

Human impact No graffiti or other impacts.

Further research

Previous treatments 2005 surfactant clean

Management issues The concrete dam wall runs across the entire width of the outcrop and there is evidence of this having effectively channelled water away from the site. There is evidence of salt flow and cement splatters that need to be removed. Siliceous grouts should replace cement in time. This site may be the ideal test site for siliceous grout dams and whether they need siloxane or acrylic water proofing.

8.7. Teit Tong Tsui (Joss House Bay)

Site name	Teit Tong Tsui
Subsite name	
Title type	Government Land
State	Hong Kong
Painting or Engraving	Engraving
Support surface length	2.300
Engraved area length	1.500
Engraved area height	2.100
Dripline distance	0
Height at dripline	2.500
Existing documents	Reports held by client
Subjects	Character panel recording visit to nearby temple in 1274
Date	1274
Dating method	Taken from inscription.



Dating potential No further dating required
Solar window coordinates Not recorded but faces west and trees to the west provide almost complete shade in afternoons.

Vegetal shade value
 As above, trees to the west provide valuable shade to reduce thermal impact on surface.

Surface slope 85-90
Floor type Rock strewn soil covered hill slope but not currently visible in front of site.
Terrain below site Steep soil covered hill slope west down to the sea approximately 100 metres away.
Terrain above site Gentler soil covered slope for several hundred metres of wooded terrain.

Rock type general
 Granite with inclusions of earlier basalt up to 250 mm and areas of pure feldspar crystals. The geological map describes the location as Trachydacite or trachyte lava but the boulder may well have been dislodged for the granite fields (gc) further up hill.

Morphology Rounded boulder.

Description, brief
 Text character panel carved onto exposed surface.

Visit dates 03 11 2009, 03:52

Survey team Andrew Thorn, Eddy, Hong, Andy, Evita

Photographic record Pentax digital SLR 6Mp

Best photo time Mornings best as sun comes through in afternoon.

Moisture survey No evidence of seepage. Water washes down face but not measured. A diversion dam has been constructed on top of the boulder.

Salts distribution Not measured and no visual evidence of damaging salts.

Water wash damage Water flows into the carved area from above despite there being a diversion dam wall above.

Rock stability All stable with no micro-spalling evident on carved panel.

Ground erosion No evidence of erosion from the ground. Separated by a horizontal fissure low down below panel.

Surface alterations No substantial mineralization over surface.

Dust accumulation No dust.

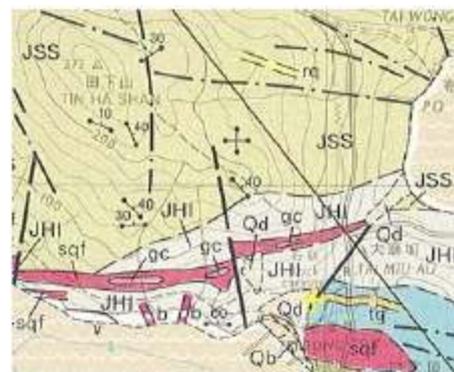
Paint stability Surviving paint is a recent addition but is now highly degraded. Current policy is to not repaint the characters which are believed to have been painted in the last two decades.

Fire risk Low, vegetation too lush.

Weeds No weeds encroach into the site.

Biological activity Biota covers the characters making them difficult to read when not controlled. Siloxane has been applied after biocidal treatments and yet the green growth is returning within three years. This is a combination of factors including siloxane not penetrating into the substrate, shade and water breaching the dam walls. There is evident water repellency on the surface but the scaly film seen elsewhere indicates that the viscous liquid is not penetrating into dense rocks. It is recommended that future control of biota at this site adopt the ethanol suppression technique, as described in earlier sections.

Animal impact No visible impact from animals.

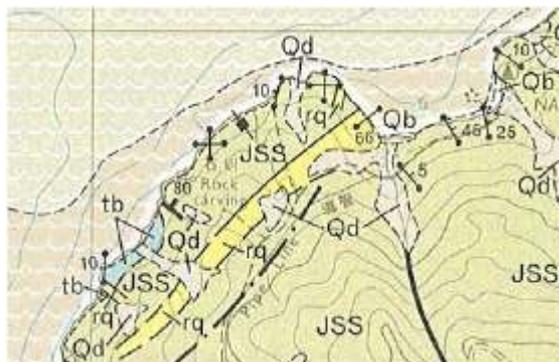


Bird impact	No evidence of birds near engravings.
Insect impact	No insect impacts.
Human impact	Red characters painted on the side of the boulder away from panel, possibly quite recent.
Further research	Treatment durability and ethanol suppression should be trialled at this site.
Management issues	

This site is very difficult to view due to the highly reflective screen. The visual setting is highly impacted by the screen and concrete viewing area. The site has been carved by an earlier visit to the temple along the shore line and this association needs to be retained. Alterations not the infrastructure are perhaps a lower priority here as it is clearly a highly visited area that needs to address the needs of park visitors and those to the temple.

8.8. Tung Lung

Site name	Tung Lung
Subsite name	
Title type	Government Land
State	Hong Kong
Painting or Engraving	Engraving
Support surface length	3 metres
Engraved area length	2.700
Engraved area height	2.500
Dripline distance	0
Height at dripline	3 metres or more
Existing documents	Reports
Subjects	Considered to be a bird or a dragon.
Date	Not known but existence recorded in 1819
Dating method	-
Dating potential	-
Solar window coordinates	Not recorded but site faces NW and therefore minimal direct sun.
Vegetal shade value	No shade other than by rock itself.
Surface slope	90
Floor type	Exposed rock benches down to sea
Terrain below site	Exposed blocks
Terrain above site	Exposed blocks becoming increasingly soil covered hill slope for some distance.
Rock type general	Difficult to assess visually but either a metamorphosed conglomerate or lava flow breccia with large inclusions. Geological map indicates Eutaxite (JSS) predominant rock in this location.
Morphology	Exposed block prominently protruding from cliff of similar blocks.
Description, brief	



Flat vertical surface facing NW on exposed durable metamorphosed lava or breccia.

Visit dates 05 11 2009, 01:57
Survey team Andrew Thorn, Hong, Karen
Photographic record Pentax digital SLR 6Mp
Best photo time

Late afternoon and early morning would provide raking light relief to best capture details.

Moisture survey No measurements taken but no immediate evidence of water flowing through the stone. Minimal wash over upper edge.

Salts distribution Not measured and no visual evidence of damaging salts.

Water wash damage Minimal water flows into the carved area from the outer rim due to the shape of the block that slopes away from the carved face.

Rock stability Rock appears generally stable with no threat to carved panel.

Ground erosion No evidence of erosion from the ground. A horizontal fissure below isolates the carved panel from lower ground water influences.

Surface alterations Cultural surface has an orange patination. Engraved channels uniquely contain a thick grey crust. Microscope study suggests crustose lichen that may have been encouraged by calcium sulphate chalking. Layer may also contain calcium oxalate as evolutionary final stage. The adjacent photograph shows the crustose lichen appearance in the lower section with a lighter grey chalking or similar evident just above it.



Dust accumulation

No dust impacting on the carved areas.

Fire risk

Too far from plants to be an issue.

Weeds No weeds encroach into the site.

Biological activity No evidence of biota impacting the carvings except the grey crustose growth in the engraved channels.

Animal impact No visible impact from animals.

Bird impact No evidence of birds near engravings.

Insect impact No insect impacts.

Human impact No graffiti or other impacts. Screen and access infrastructure very heavy.

Further research Analyse grey crust in channels to determine exact nature. It is advised that this material should be removed as it is a very obvious inclusion. This type of chalking is typical of that applied by amateur archaeologists around the world in the belief that visibility to them was more important than respect for the original work.

Management issues

The infrastructure at this site overwhelms the site and its setting. It is recommended that the presentation of this site be reviewed and that this be used as the first site, or perhaps after Po Toi, to implement low impact and low visibility infrastructure. It has been argued that the screen provides some but not substantial protection from the elements and that there are better ways of separating the panels from visitors. In fact this is the perfect site to create separation due to the severe drop between the panel and surrounding rocks.



The adjacent photograph presents the site as it stands. A blue line indicates how the viewing level could be separated by lowering it by a metre and separating the platform from the rock by at least 1.5 metres. Ideally this could be more but is limited by the need to secure the platform to rock ledges below. By lowering and moving the viewing area away from the rock face the severe drop between will prevent touching and visitors cannot approach from below due to the height and angularity of the natural rock. Under this recommendation the screen should be removed and all the concrete steps going further to the right.

8.9. Wong Chuk Hang

Site name	Wong Chuk Hang
Subsite name	
Title type	Government Land
State	Hong Kong
Painting or Engraving	Engraving
Support surface length	Very long creek wall
Engraved area length	3.000
Engraved area height	2.500
Dripline distance	0
Height at dripline	5.000
Existing documents	
Site reports held by Office	
Subjects	Geometric patterns.

Date -
Dating method -
Dating potential -
Solar window coordinates 180-360, facing east.
Vegetal shade value

This site is exposed to midday sun but at an acute angle. Vegetation reduces this further but not critical due to carving orientation away from sun.

Surface slope 85-90°
Floor type Rocky stream blocks.
Terrain below site Creek bed with flowing water.
Terrain above site Steep rock wall turning into soil covered slope of around 8-10 metres.
Rock type general

Geological map indicates this to be a fine ash vitric Tuff (JAC). This is difficult to confirm visually.

Morphology Vertical cliff wall.
Description, brief Engraved geometric forms on vertical cliff face.
Visit dates 07 11 2009, 04:21
Survey team Andrew Thorn, Eddy,



Hong, Karen

Photographic record Pentax digital SLR 6Mp
Best photo time Shade all day due to narrow view to direct sun at midday. Any sun will enhance engravings but otherwise full even shade.

Moisture survey No measurements taken but evidence of water wash down the south end of the rock away from engravings. Dam above appears to deflect most water from hill but is clearly leaking in the southern section.

Salts distribution Not measured and no visual evidence of damaging salts. There is potential for salt formation due to soil above and concrete capping of the hill slope.

Water wash damage Water washes down from the 8 metre vegetated slope above. The current dam intercepts most of this.

Rock stability Rock appears moderately stable but there is some degree of friability in the outer altered surface. There is no urgent need to consider consolidation of this surface but its condition needs to be monitored.

Ground erosion Engravings are well above water level currently and any rising moisture associated with this.

Surface alterations Cultural surface has pale yellow engraved channels of same colour as immediate background. Some deeper orange in some background areas.

Dust accumulation No dust impacting on the carved areas.

Paint stability -

Fire risk Too far from plants to be an issue.

Weeds No weeds encroach into the site.

Biological activity Strong biological staining in some places but less apparent in engraved areas. These have received water repellent. Surface had stronger presence of green algae before treatment.

Animal impact	No visible impact from animals.
Bird impact	No evidence of birds near engravings.
Insect impact	No impact from insects.
Human impact	No graffiti or other impacts.
Further research	

Management issues

This site provides a useful study in access separation. The viewing platform is separated from the panel by at least 5 metres and this makes the engravings slightly difficult to appreciate for the casual visitor. There is no suggestion that this should be modified but it does allow a judgement of the appropriate separation distance for boardwalks at those sites where changes are recommended. For now it is satisfactory to leave the infrastructure as it is and that any changes should take place once the current platform requires upgrading.

There is little likely impact from the concrete viewing platform as it is separated from the site by a flowing stream. There is a greater danger from the cement used to cap the hill slope above the site. It is understood that the slope stabilization has not been as a protective measure for the engraved panel but nonetheless it has potential impact through the release of soluble salt. Alternative soil stabilization measures should be sought for this hill slope which may include an alternative covering or benching that allows plant regrowth to bind the soil.

Previous treatments

2006 surfactant clean and moss removal, biocidal treatment, siloxane hydrophobic treatment.

9. References

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