5 The Rock Art Stability Index

A Non-Invasive Rapid Field Assessment for Condition Evaluation

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Introduction

That rock art represents an interdisciplinary endeavour would most likely not be disputed. This is reflected in the number of different techniques used to evaluate these priceless heritage resources, which number perhaps close to 100, including this volume, its predecessor, and other multiple other studies (cf., Barnett et al. 2005; Darvill and Fernandes 2014; see also Fitzner, Heinrichs and La Bouchardiere 2002, 2004; Giesen et al. 2013; Hoerlé et al. 2016; Pineda et al. 1997; Pope 2000; Tratebas, Cerveny and Dorn 2004; Wasklewicz et al. 2005). Still, none of these truly offer a rapid, low-cost, easily accessible, non-invasive, field-based assessment of a host panel's inherent geologic characteristics. Even the recent Condition Assessment and Risk Evaluation (CARE) project (see https://rockartcare.ncl.ac.uk), though useful for documenting a panel's general *surrounding* conditions, has a lone, single opportunity to rate "erosion" (and in a yes/no fashion *only*), though stone deterioration mechanisms remain much more in-depth than "erosion" alone.

Gaining insight into a rock art panel's geologic and geomorphologic stability, therefore, represents a first step in managing this priceless component of cultural heritage for future generations. In fact, while perhaps not as flashy as other geo-heritage offerings, rock art nonetheless plays a role in tourism – in some places more than others. Most every country in the world hosts some type of rock art, and often even highly significant (and sacred) sites remain open to the casual tourist. A limited number of these rock art sites are well-funded enough to receive intense supervision and careful curation. Most, however, are left to the elements with perhaps a lone caretaker to watch them deteriorate. Being able to quickly and accurately assess a rock art host panel's geologic stability then remains an important aspect for many of these sites since rock art also represents an important tourism component.

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More than a decade ago, Cerveny (2005) conceived an alternative technique to assess a rock art panel's geologic stability – giving researchers a way to quickly and effectively evaluate areas at-risk. This new technique focused on combatting the often costly and time-consuming assessments that centred more around built stone (e.g., architecture) and paid little attention to rock art specifically, let alone rock decay science (i.e., "weathering"[1]). The result of Cerveny's work, the Rock Art Stability Index (RASI, see Dorn et al. 2008), has since been used throughout the world to assess the geologic stability of thousands of rock art panels (cf., Allen and Groom 2013a, 2013b; Gharib 2020; Groom et al. 2019; Wright 2018). Even more importantly, RASI demonstrated not just replicability among trainees (Cerveny 2005; Dorn et al. 2008), but later showed that those trainees gained even deeper understanding of rock decay forms and processes, connecting their analyses to the larger landscape while gaining a greater sense of appreciation for rock art itself (Allen 2008, 2011; Allen and Lukinbeal 2011; Groom, Bevan and Allen 2018; 2020; in press). The technique has also been further validated using scanning electron microscopy (SEM), where observed decay forms correlated with SEM analyses (Cerveny et al. 2016), adding even more support to RASI's veracity. Additionally, since 2014, an adapted version of RASI has been developed, termed the Cultural Stone Stability Index (CSSI), and has been in use to assess historic buildings and monuments with similar success (Allen et al. 2018; Groom 2017; Hayes and Hayes 2019).

Though often conducted with pen-and-paper, RASI can still be completed quickly, and even on-the-fly *in situ* (Allen et al. 2011). With the addition of an electronic version of RASI currently using ESRI products, but with a specifically developed smart phone app currently being created by Stone Heritage Research Alliance (SHRA), field collection and data storage/analysis has been further enhanced. An example of this RASI e-version is highlighted in Chapter 3 of this volume. What this enhancement means, is that tying RASI into a Geographic Information System (GIS) can now be done without manually entering tabular data, allowing for correlation between rock art site/panel and specific decay forms/processes, as well as providing locational attributes more efficiently (e.g., Allen et al. 2011; Dorn et al. 2008). With more detailed analysis by a trained RASI analyst, specific problem areas (and their causes) on a host panel can also be pinpointed. Though not for specifically protecting rock art, with a short training period (e.g., weekend workshop) including an *in situ* component, RASI can be used by any rock art aficionado, irrespective of their previous background knowledge in rock decay science, archaeology, geology, or any other discipline. Even further, RASI's cost-effectiveness allows site managers to determine where best to spend their precious funds, and which panels may need more intensive and specialized treatment such as those noted by Viles et al. (1997) and Fitzner (2002). Based on sound principles of rock decay science – and much evaluation of validity and replicability (see Dorn et al. 2008 for full details) – RASI meets this perceived need, serving as a powerful technique in terms of open-air rock art management strategies, providing "triage" services for a site manager, and allowing for a quick snapshot of potentially endangered panels and sites.

To demonstrate the power of RASI as an open-air rock art management and conservation technique, consideration is now given to a broad overview of RASI, outlining its specific parameters and rating system. After highlighting RASI's successful uses around the world, a recent case study is offered as an example of how RASI might be used in a "wild" (i.e., unmanaged) open air setting. The case study focuses on two heritage sites on the Caribbean tri-island nation of Grenada where no regulation or official management strategy occurs. What monitoring is done in Grenada, aside from annual RASI assessments, remains haphazard at best, and there is not yet an official management plan. Drawing on the case study and its usage in different world locales, the final discussion in this chapter focuses on RASI's overall usefulness and applicability as an open-air rock art management technique, including potential implications its use may have for the rock art research, conservation, and sustainability communities.

Nuts and bolts of RASI

To classify the more than three-dozen distinct rock decay forms, RASI utilizes six overarching categories: site setting, impending/future loss, incremental erosional loss, large erosion events, rock coatings, highlighting vandalism and other issues. The first category, "Site Setting", evaluates a panel's basic geologic parameters (e.g., rock weakness and fissures/cracks). "Impending Loss," RASI's second category, assesses possible future forms (and potentially locations as well) of decay (e.g., scaling and undercutting). The third overarching category, "Large Break-off Events," focus specifically on meso-scale decay events that have already occurred (e.g., anthropogenic activities and fire). "Incremental Loss," RASI's fourth category, includes relatively small-in-size decay forms, such as lithobiont pitting (i.e., algae, lichen, and mosses) and granular disintegration. More than one-dozen rock decay forms are included in this fourth category, since rock decay forms at the micro scale (centimetre or millimetre) tend to be most abundant across all rock types. The fifth category, "Rock Coatings," represents an important concept often overlooked in other rock art assessment indices. In natural stone (as opposed to worked stone in architecture and building instances), rock coatings often serve to strengthen the overall rock, and RASI reflects this understanding by adding a negative value (i.e., 0, -1, -2, -3) to each of the respective forms, lowering the total score. A final, sixth category, "Vandalism and Other Issues," is also included in RASI. While its qualitative nature does not figure into the overall RASI score, it allows the researcher to highlight any other observations they may deem as affecting the host panel (e.g., graffiti and land use issues).

That RASI evaluates a wide range of forms (driven by their respective processes) means it can give the site manager and conservator a good handle on not just the intensity of a decay form, but potentially the specific cause of that decay. To recognize decay features and subsequently understand the processes behind their creation, however, requires training. The SHRA maintains an active website that offers a brief overview of RASI and its importance, as well as publications from SHRA members and collaborators[2]. In all cases, as with other specialized assessments across disciplines, parties interested in using RASI should always be trained appropriately by those with both experience conducting RASI assessments as well as expert knowledge related to rock decay processes and their subsequent forms. The SHRA represents the only entity to provide RASI certification at three levels: Basic, Analyst, and Trainer. Part of the SHRA's official RASI training is carried out *in situ*, whether in small groups or individually, as studies demonstrate hands-on practice with RASI in groups of fewer than 10 people results in the deepest understanding (Allen 2008, 2011; Allen and Lukinbeal 2011; Cerveny 2005; Dorn et al. 2008).

After completing specialized training then, potential RASI researchers gain practical experience in recognizing specific rock decay forms on a host panel associated with the first five categories, and rate each on a 0–3 severity-of-occurrence scale:

- Ranking of 0 ("Not Present"), where the rock decay form is not found on the host panel.
- Ranking of 1 ("Present"), where the rock decay form *is* found on the panel, but not specifically touching the rock art/glyphs/motifs.
- Ranking of 2 ("Obvious"), where the rock decay form is inflicting damage to the rock art/glyphs/motifs.
- Ranking of 3 ("Dominant"), where the rock decay forms are directly and dominantly impacting the rock art/glyph/motif.

After assessing the degree of each rock decay element individually, the rankings are tallied to create a "raw score", and then doubled for a panel's "final score". A RASI score ranges from 0 to 100 (a score of more than 100 is possible, but a panel would likely be unrecognizable as such with a score approaching 100), and when it comes to a panel's score, the lower an overall score, the more geologically stable a panel is. To enhance RASI's administrative function, overall score range classifications remain descriptive:

- 20: Excellent Condition.
- 20–29: Good Status.
- 30–39: Problem(s) that Could Cause Erosion.
- 40–49: Urgent Possibilities of Erosion.
- 50–59: Great Dangers of Erosion.
- 60: Severe Dangers of Erosion

As volunteers remain a staple for rock art awareness and assessment, one of RASI's main functions was to increase accessibility for non-specialists, irrespective of previous background. As illustrated above, the index therefore contains limited technical jargon, and where such verbiage must be used (e.g., "fissuresol"), even more time is spent explaining the form (and its precursory/resultant processes) during the training process. With a weekend workshop – one-three days spent in a classroom setting learning about rock decay forms and another day or two in the field practicing with a RASI professional – a person with no previous experience in archaeology, geology, geography, or rock decay science can be ready to fully utilize RASI. While these trainees may not necessarily have in-depth understanding of the process(es) behind each rock decay form's creation or petrologic significance, they learn to recognize specific forms that have potential to lead to a host panel's instability. Even though further training remains necessary to fully understand and interpret underlying decay processes – and the SHRA provides certification in this area – a basic RASI assessment provides a useful snapshot of a panel's overall geologic condition and stability in terms of decay. If a more in-depth analysis of the site in terms of its condition is required, a trained *rock decay scientist* (and/or trained RASI professional) can offer one, based on the specific scores of each category and decay element.

Cost also figures into rock art management plans, with a lack of monies usually inhibiting traditional research efforts. As RASI does not require long-term coursework, training, or laboratory-based apparatus or analyses, cost savings are significant. This allows managers to more appropriately allocate their (usually limited) funds. Obviously, when significant funds are available, more intense laboratory studies can help generate further benefits such as developing site-specific mitigation and/or management methods (c.f., Fitzner, Heinrich and La Bouchardiere 2002). Therefore, RASI provides a unique alternative that can immediately influence management and conservation efforts to both well-known and newly discovered sites. Additionally, RASI scores can be easily added to GIS, allowing for correlation and spatial analysis of not just site or panel distributional characteristics, but also specific decay patterns and phenomena even on the panel itself (Allen et al. 2011; Dorn et al. 2008).

Finally, unlike other rock art assessment techniques, RASI allows local communities to readily assist in the management of rock art. RASI has the potential to enhance local buy-in, cooperation, and personal investment. It also creates "Citizen Scientists", where individuals can gain experience utilizing and understanding science (geology and rock decay in this instance) in terms of resource management (Allen 2008; Allen et al. 2011; Allen and Lukinbeal 2011; Groom et al. chapter 15 in this volume). Ultimately, RASI represents an exemplary technique for open air rock art management by providing a rapid, non-invasive, and cost-effective way to engage local communities – helping to generate significant awareness about rock art, while also providing the site manager with timely, useful, and in-depth analyses of a host panel's overall and specific geologic stability.

Previous implementation of RASI and case study

From an applicability standpoint, RASI has been implemented in a myriad of locations, on different rock types, and by different (trained) research cadres. Since its inception, a few studies helped lay RASI's foundation as both a rock art assessment and a pedagogical tool. The technique's replicability (Cerveny 2005) and usefulness as a pedagogy (Allen 2008, 2011) were conducted in the Sonora Desert alongside another study that demonstrated how RASI aided non-rock decay specialists in connecting complex biophysical processes to the greater landscape (Allen and Lukinbeal 2011). Soon after the initial trials, RASI was applied to research undertaken by three universities (Arizona State University, Mesa Community College, and University of Colorado Denver) as part of a NSF grant and two CESU grants from 2008–2012. While these grants served both educational and research initiatives, each was focused on utilizing RASI to examine the thousands of Native American petroglyph panels found in PEFO while also (re)recording rock art panels' locations and motifs, and then evaluating them for geologic stability quickly (Allen et al. 2011). Indeed, over a four-year period (2008–2011) with only a few weeks in the field per year, approximately 100 trained volunteer researchers assessed nearly 3500 individual panels in that timeframe[3].

A year after the RASI assessments at Petrified Forest National Park (PEFO) in 2012, a small team of trained RASI researchers conducted the first stability assessment of Grenada's "Carib Stones" at two sites: Duquesne Bay and Mt. Rich (Allen and Groom 2013a, 2013b). Annual monitoring of these sites over the next several years revealed some interesting (and perhaps unknowingly, but potentially slightly detrimental) local management practices (Groom 2017). RASI has also been paired with historic repeat photography to yield an even richer analysis of (semi)protected sites in the Arkansan Ozarks (Groom 2016), as well as assessing the geologic stability of ancient inscriptions in Wadi Rum, Jordan (Chapter 15 in this volume). While RASI assessments were on-going in Grenada, during 2015 and 2016 specifically, a research team reassessed the Duquesne Bay and Mt. Rich sites, and two additional rock art sites, each situated immediately adjacent to the Island's main road in the villages of Victoria and Waltham (Figure 5.1).

The RASI's efficiency as an open-air rock art management technique aids site managers in not just basic recording of panel locations and motifs, but also provides a quick, non-invasive geologic assessment of these priceless heritage cultural resources, and these characteristics play critical roles in rock art management strategies. To showcase these abilities, a recent (but abbreviated) case study using RASI to evaluate two previously unassessed sites follows.

Figure 5.1 Location of RASI-assessed rock art sites on the Island of Grenada, West Indies (Caribbean), displaying their precarious locations next to the main ring road (Victoria and Waltham), the beach (Duquesne Bay), and interior rainforest in a perennial river (Mt. Rich). Map by K.M. Groom.

Grenada's "Carib Stones" at Waltham & Victoria

Located roughly at 12 degrees north latitude in the West Indies – approximately 150 km north of Venezuela – the tri-island nation of Grenada hosts a tropical, though monsoon-like climate. Classified as a Small Island Developing State, its economy relies heavily on tourism and agriculture. Known as "The Isle of Spice", this tiny nation produces fragrant spices such as cloves, allspice, and cinnamon, as well as roughly one-third of the world's nutmeg. Popular tourism sites include the Spice Market in St Georges, various waterfalls, the central rain forest, pristine white and black sand beaches, and the Amerindian rock art. Inhabited since pre-Columbian times by various peoples, both the Arawak and Carib Amerindians settled on Grenada for extended periods. Each followed the assumed south-to-north migratory path of Caribbean Amerindians, though dates of their occupations are mostly contextual and based on artefactual evidence

(Huckerby 1921; Martin 2013; Steele 2003). While Grenada's petroglyphs are known locally as the "Carib Stones", they are more likely the product of Arawak peoples rather than the Caribs, based on motif design (Dubelaar 1995; Hayward, Atkinson and Cinquino 2009; Marquet 2009). According to these authors, five or six main petroglyph sites have been located on Grenada, though at least one of these known sites hosts only grindstones/cupules, and locals also refer to these as Carib Stones. Still, Grenada's rock art sites host more than a hundred individual motifs, making them one of the richest concentrations of petroglyphs in the Lesser Antilles. Although unprotected and highly under-studied, Grenada's Carib Stones represent a priceless, cultural heritage resource which requires further immediate attention and management.

Without further awareness and condition assessment, Grenada's priceless heritage resources could be in danger of disappearing altogether. For example, despite good intentions, a local group of volunteers "cleaned" the Mt. Rich petroglyphs in mid-2015, unknowingly removing the various natural protective rock coatings, potentially destabilizing the site until a protective patina returns. Reassessing the site a year after the cleaning occurred demonstrates resilience of some panels, but less so on others (Groom 2017). The possibility for this well-meaning but inadvertent potential damage to happen at other sites – especially the Victoria and Waltham sites which sit next to the main road and in people's yards, respectively – puts the Carib Stones in a precarious management situation.

In Grenada, the Carib Stones are not yet protected officially by any entity. Subsequently, most sites are treated differently based on their location, leading to multiple management strategies depending on a site's location. While these sites have tourism potential – visitors to Grenada are often taken to a site or two by local tour companies – maintenance and upkeep represent key issues that need to be considered. Management of Grenada's Carib Stones is also a delicate endeavour, given their unofficial status as a heritage resource: they currently belong to the residents and local communities, not the tourists or government. Finding a balance between governmental and local management strategies and plans can be challenging.

Consideration is now given to both the examples in Victoria and Waltham, including implications to Grenadian tourism and subsequent informing of local management professionals of potential threats to these important heritage resources through the RASI examination. Simultaneously, these studies have also helped provide valuable insight into Grenada's history, as well as placing these little-known petroglyphs into the spotlight through potential sustainable tourism initiatives. While the Duquesne Bay and Mt. Rich sites were annually assessed with RASI from 2012 to 2016 (cf., Allen and Groom 2013a, 2013b), not until the summers of 2015 and 2016 was RASI employed at two other known petroglyph sites in Victoria and Waltham, both located on the island's western side.

Victoria site RASI assessment

Containing a single boulder with two panels, the Victoria site rests between the main road's retaining wall and the Caribbean Sea, and directly adjacent to a storm drain (Figure 5.2). In Grenada, all beaches are deemed public to the high tide mark. For the Victoria site, this means that, because it sits at the ocean's high tide mark on one side and the main road at the other, the site is technically on public land, creating unique challenges for conservation, as well as tourism. The host boulder was deemed too important to lose when the road was being reinforced, and it was partially cemented to the road's retaining wall, just above the storm drain. Locals will often tell tourists that another boulder with glyphs used to sit next to this one, but it was removed when the road was widened, and no one knows its current location. Although trash dumping is an illegal act on the island, the storm drain has been used for this purpose, as well as an impromptu shelter. The host boulder also rests just a few meters away from the ocean, leaving the panels open to storm surges and potential climate change-driven sea rise. Finally, because of its location on public land, stopping locals from washing and re-etching the art is a challenge. For example, during initial data collection in 2015 and follow-up assessment in 2016, a local picked up

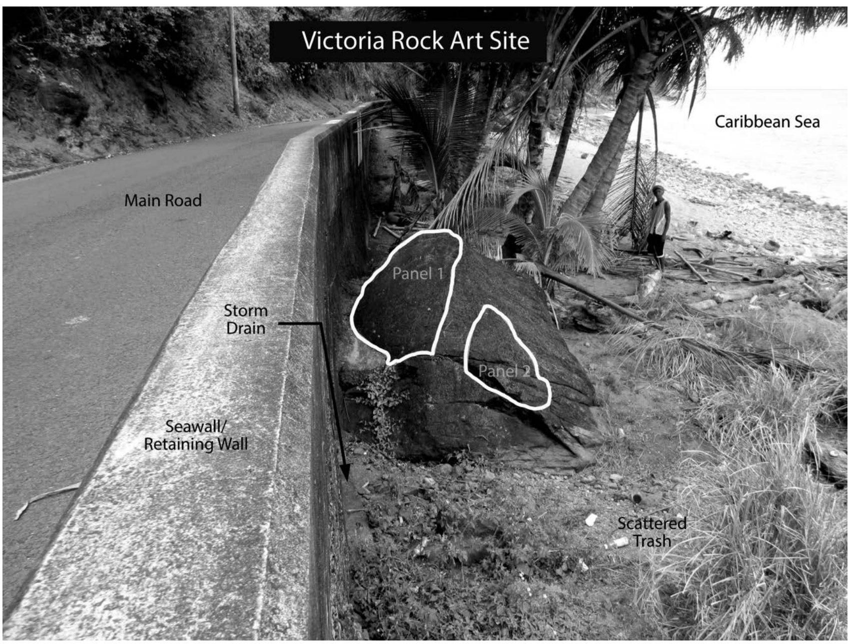

Figure 5.2 The Victoria site hosts two panels on one boulder, each with a single face glyph. They rest next to the main road, adjacent storm drain and the Caribbean Sea – the latter two of which, during storms, partially inundate the boulder. Photo by C.D. Allen 2015.

a rock and began outlining the motifs, wanting to make them more visible for the "tourists", and perhaps earning a small tip for the effort. This type of behaviour remains typical for many unofficially protected rock art sites around the world, though researchers seem to differ on its appropriateness (Whitley 2001).

Panel one assessment

Splintering occurs on the face glyph (Figure 5.3a), including splintering bisecting the glyph's top left corner. The lithological differences and inconsistencies responsible for this decay form can become more apparent – and thus, more damaging – over time. Lithobiont growth is also obvious, growing on the glyph itself, as well as scaling at the glyph's base. Recent scratching from a local "caretaker" to make the glyph more visible for tourists was also visible in assessments both years. The splintering on the glyph's upper left corner remains consistent, though not as readily visible due to lighting and lack of rain in the 2016 image (Figure 5.3b). Scaling and lithobiont growth are also present with some of the lichen growth from 2015 being both desiccated and detached. Most notably, a termite trail runs through the glyph in the 2016 image (Figure 5.3b). While part of the boulder is held in place with retaining/seawall concrete, it remains susceptible to damage from water and

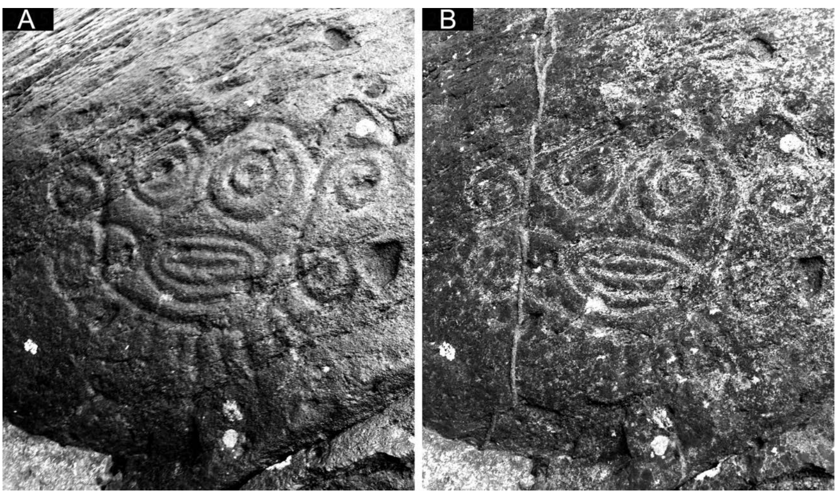

Figure 5.3 (a) Panel 1 at the Victoria site displaying some splintering, particularly in the upper left of the image where the rock exhibits condensed linear cracks, as well as flaking and crumbling from perhaps continual abrasion (2015). (b) Comparative image of Panel 1 at the Victoria site displaying splintering, particularly in the upper left of the image where the rock exhibits condensed linear cracks, as well as flaking and crumbling from perhaps continual abrasion (2016). Photos by C.D. Kennedy.

debris carried in the adjacent storm drain and storm surges during the rainy season. This panel earned RASI scores of 41 in 2015 and 44 in 2016 ("Urgent Possibility of Erosion").

Panel two assessment

Located on the north side of the boulder and difficult to see in direct sunlight like panel one, panel two consists of a simple face with eyes and a mouth. Compared to panel one, striations indicating splintering and subsequent scaling under the glyph remain more visible on panel two. Evidence of re-etching is evident in the scratch marks inside the grooves of the glyphs. As with panel one, this panel remains under perpetual threat from the storm drain and the Caribbean Sea. Panel two received RASI scores of 51 in 2015 and 53 in 2016 ("Great Danger of Erosion"), with the slight score change due to additional scratching present in 2016. In the RASI score sheet notes, suggestions were made that panel two could potentially be more contemporary – based on motif style – although the decay rate and aging signs seem similar to panel one.

Overall, averaging scores from both panels among several different researchers, the Victoria site scored 46 in 2015 and 48.5 in 2016 ("Urgent Possibility of Erosion"). Major concerns include the trash disposal in the storm drain adjacent to the boulder, proximity of the ocean, as well as residents re-etching the glyphs (which removes potentially protective patinas). Given these urgent factors, the one-point difference in RASI scores between 2015 and 2016 speaks to this rock type's resilience. The next scheduled RASI field visit to these sites is planned for 2020.

Waltham site RASI assessment

Just north of Victoria lies the village of Waltham, with two boulders located in the front and back yards of two separate residences (Figures 5.4 and 5.5). Along with the environmental concerns, how the landowners treat the Carib stones needs to be considered as well. For example, during data collection, one resident mentioned someone had suggested cleaning the boulder, but they were unsure if this was good for the motifs. A further consideration is that as the glyphs rest on private property, and the landowners can ask for compensation in return for seeing or studying the rock art. These challenges influence the way management efforts can be organized, especially where rock art on private land is concerned.

Panel one assessment

Facing almost due west and located a few steps from the main road panel one stretches over a large, flat-lying boulder. Three face glyphs were identified, one of which can be described as very simple, similar to the motif on panel

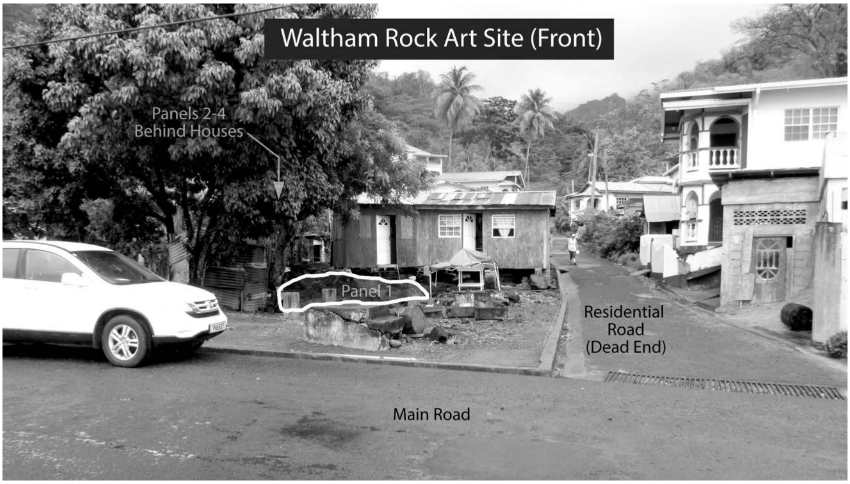

Figure 5.4 Waltham site setting (front view) consisting of four panels on two different boulders near the island's main road – with the Caribbean Sea directly opposite – as well as a side street, houses, plant life/detritus, rubbish piles, and free-range livestock, pets, and people. Photo by C.D. Allen.

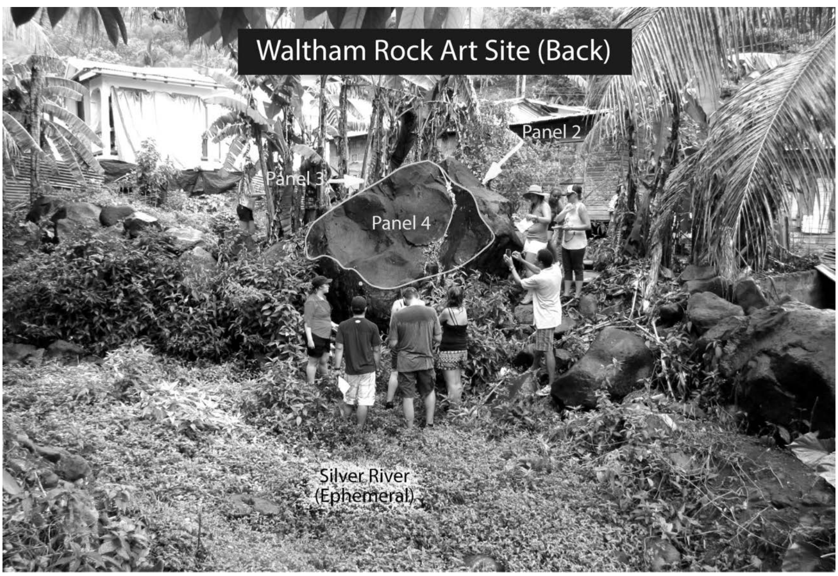

Figure 5.5 Waltham site setting (rear view) of boulder hosting panels 2, 3, and 4 perched precariously the riverbank and near several houses, some of which contain both penned and free-roaming livestock, along with agricultural debris, rubbish, rubbish burning, and children using the boulder for fun activities such as climbing. Photo by C.D. Allen.

two at the Victoria site which was speculated to be more contemporary than historic. In 2015, this panel was assigned a RASI score of 36 ("Problems that Could Cause Erosion") and earned a score of 40 in 2016 – barely hitting the "Urgent Possibility of Erosion" score range. Reviewing the RASI score sheets in more depth suggests that the slight increase in score is due to more plant and animal activity at the time of the assessment in 2016 (it was raining during the 2015 assessment), as well as loss of rock coating.

Panel two assessment

The first of three panels hosted on a tri-facet boulder surrounded by foliage, trees, and a large rubbish heap, panel two faces southeast toward a small grouping of houses and local road. This panel contains multiple face glyphs, and what is thought to be a rudimentary body motif. The main decay features occurring on panel two include abrasion from the surrounding vegetation, lithobiont growth and release, and termite trails running over the boulder. In 2015, the panel was given a RASI score of 36, and assigned a score of 38 in 2016, with the slight score increase most likely due to more vegetation growth and lithobiont activity from a very active wet season (both scores still fall within RASI's "Problem(s) that Could Cause Erosion" score range).

Panel three assessment

Located on the western side of the boulder, and sloping downward toward the riverbed's south bank, panel three hosts multiple face glyphs, as well as what could be interpreted as a diamond-shaped kite. Dense foliage ("plant growth on/near panel") and proximity to the river (potentially leading to undercutting or even slope failure, landing the boulder *in* the riverbed) remain the primary concerns with panel three. Assigned a RASI score of 36 in 2015 ("Problem(s) that Could Cause Erosion"), it earned a RASI score of 26 ("Good Status") in 2016. Like all panels at the Waltham site, the difference in weather (it was raining heavily during 2015's assessment) could affect lighting, with decay features perhaps being clearer in the rain and corresponding low light, though there was noticeably less trash near the panel in 2016 and less lichen as well, each of which could contribute to this slight score change. This downward score movement also represents an example of why continued monitoring by a trained researcher remains necessary for a visual assessment technique such as RASI: so that data from panel can be analysed in-depth for specific change in RASI elements.

Panel four assessment

Facing north towards the riverbed, hosting multiple fissures and resting precariously on the riverbank, panel four at the Waltham site also remains continuously surrounded by vegetation (see Figures 5.5). The main glyph, a two-faceted face, can barely be seen even in the low light and rain. Termite trails on the boulder's underside serve to destabilize the rock matrix over time (biological decay), and scaling – impending, future, and existing – has influenced this panel's overall stability (light-coloured area of boulder, bottom right side of figure 12). In 2015, panel four earned a RASI score of 55 ("Great Danger of Erosion"), and a RASI score of 47 in 2016 (at the low-end of "Problem(s) that Could Cause Erosion"). Again, as with panel three, lighting played a role in the large scoring difference here, as did angle of assessment: in 2016, the amount of vegetation limited access to the same viewshed that was used in 2015. Continued and regular monitoring via RASI can help tease out the reasons behind the slight score change and, as with most scientific endeavours, additional data can lead to more refined analyses, providing greater detail and accuracy.

Taking each panel's average score, the Waltham site overall had a RASI score of 41 in 2015 (at the low-end of "Urgent Possibility of Erosion") and a 38 in 2016 ("Problem(s) that Could Cause Erosion"). The backyard boulder that hosts panels two-four is in danger from abrasion due to the trash heap, the dense undergrowth, in addition to the banana and palm trees very nearby, as well as the large lithification-independent fractures and undercutting that has occurred and will continue to occur in the near future. The lower score in 2016 occurred because vegetation and rubbish had been removed, meaning abrasion was no longer a top concern. Still, the major concerns facing the entire Waltham site include the land use, vegetation, and potential hazards due to the river's proximity. Another challenge here lies in the fact that the two boulders that have glyphs sit on private property, so any conservation efforts would have to go directly through the landowners, an increased challenge for protecting the sites.

As illustrated here, at a minimum, regular monitoring should occur for all Grenadian rock art sites, especially surrounding the potential erosional threats at each site: this includes examples from the case studies such as the ocean and adjacent dwellings at Victoria and Duquesne Bay, the proximity to free-range animals, dense vegetation, the nearby river and surrounding houses at the Waltham site, and the precarious location of the Mt. Rich site *in* the river also surrounded by dense vegetation. Indeed, since intuitively, rocks should decay over time instead of becoming more stable, data from continued RASI assessments are necessary to ultimately generate a more complete picture of each rock art panel and their decay parameters, which in turn can lead to specific management strategies.

Discussion and implications

The RASI not only addresses contextual differences, but also adapts to any environment or conservational/management challenge. For example, in harsh desert environments, intrinsic sandstone weaknesses are reflected in the RASI analyses with higher scores of flaking, splintering, and undercutting. These concerns were shared with the National Park Service though direct participation of park rangers and volunteers, allowing rapid implantation of alternative policies and tourism planning related to sites assessed at Petrified Forest National Park. Alternatively, the sites of Grenada's Carib Stones exhibited different threats from land-use, plant activity, and precarious locations. The challenges with applying strategic and integrated official management leave these sites vulnerable to both natural decay processes and unintentional impacts from unbridled tourism development – a necessary and dominant economic force in most developing nations.

Although there are many people who advocate that rock art could be more protected than it is, there appears to be a portion of the population in many locations that have little to no interest in preserving these sites for future generations. While this may relate to traditional belief systems, socioeconomic factors, or otherwise, a potential method to help garner interest would be to approach a management proposal from an economic perspective. For example, informing local communities that these sites can be used for financial gain may increase the desire to protect them. In any case, simply involving local communities in both data gathering and dissemination can be empowering for them, making it easier to include local populations in the overall management plan, especially since engagement with tangible cultural heritage has been shown to increase appreciation for management and preservation issues (cf., Allen 2011; Basu and Barton 2007; Tal and Morag 2007). Researchers can also share information with the community about how to conserve, manage, and protect rock art which may help inform local decisions about how to approach the management of the sites (cf., Groom et al., chapter 15, this volume). Specifically, information on preserving a specific rock art panel may be needed, as reports about well-intentioned "researchers" cleaning the surface of the boulders, re-etching/chalking the petroglyphs, and even removing entire panels have been discussed around the world (cf., Kivikäs 2001; Lee and Stasack 1999; Ritter 2010; Ziolkowski 1998). Though some of these actions may be well-intended to, for example, make the motifs more visible for the tourist and/or rock art aficionado or to better record the imagery, in most cases due to the host stone's geologic structure, those actions have the potential to damage the rock art and create new weaknesses that may lead to faster rock decay and glyph disappearance. Of course, this also depends on the reasons for chalking, (re)painting, and even re-etching, since sometimes these efforts represent the only means of continuing tradition or preserving the motifs (but such efforts should be part of any long-term management plan, cf., Swartz 1963; Walderhaug 2000; Ward 1987; Welsh 1995). Still, if time, money, and expertise are available, one remedy to such potentially invasive techniques rests in utilization of high-end equipment for visualization, recording, and assessment of rock art (Alexander, Pinzand and Reinbacher 2015; Domingo et al. 2013; Horn et al. 2018; Mark and Billo 2002; Simpson et al. 2004; Vogt 2007; Vogt and Edsall 2010; Wasklewicz et al. 2005). If funds and technological proficiency are lacking, however, RASI remains a viable alternative assessment to monitor deterioration rates of rock decay over time, while also providing a snapshot of current decay characteristics.

Many open-air rock art management challenges arise from the diversity of techniques used to create the images, as well as differing contextual landscapes in which the world's rock art exist – requiring flexibility and adaptability in their assessment. Rock art has been discovered in a myriad of different lithologies and environmental settings, each presenting its own conservation risks and benefits. Pecked petroglyphs on heavily varnished sandstone in a remote desert cannot be expected to decay the same as incised motifs on an algae-infested basalt boulder in the middle of a Caribbean village. Yet, this is an assumption often repeated by research and conservation methods too rigid in their application. The wide range of rock art locales and their different inherent characteristics necessitate the employment of flexible landscape-independent techniques like RASI, which can function in any environment, on any kind of host material, and still provide relevant case-specific information. Consistently employing rapid, low-cost assessments could be one way to instigate at least basic management approaches, as well as involve local stakeholders in longer-term monitoring and management strategies.

As a triage for rock art management, RASI can help alleviate some management pressure, satisfying the above criteria because, at its core, the technique focuses on assessing a host panel's geologic stability in a straightforward and accessible manner. With precise, yet not time-consuming training, the technique is readily available and applicable. Additionally, RASI offers the site manager a way to create community buy-in, while also providing a quantifiable, empirical assessment of their site that can be used to determine where to best spend their usually limited funds in terms of managing their priceless heritage resource: rock art.

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Notes

1 Like other researchers (e.g., Dorn et al., 2013), we support the term "rock decay" (or "stone decay") rather than "weathering" because, as Hall et al (2012, p. 9) note, "...we need a term that reflects the reality of what is happening more accurately."
2 https://www.shralliance.com/rasi
3 As evidenced in a short video of the 2011 research experience involving undergraduate students, Native American high school students, and K-12 teachers from Colorado and Arizona: http://www.youtube.com/watch?v=QbhRahgRzg4.

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