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GEOARCHAEOLOGY OF THE CAVES OF BARBADOS, WEST INDIES

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Barbados is geologically and geographically distinct from the volcanic island chain of the Lesser Antilles Arc. Its unique geography and geomorphologies (both coastal and inland) have been key factors in determining archaeological, historical and modern land uses. Surface archaeology on Barbados has documented many key cultural sites which have yielded important insights into pre- and post-contact cultural patterns, however, the detailed examination of caves as similarly important archaeological and historical repositories has been comparatively limited with only two cave sites associated with formal excavations. Recent fieldwork integrated a more complete understanding of speleogenetic processes that have shaped the complex karstic landforms of Barbados with cultural resource inventories at key cave sites, documenting rock art, shell material, non-lithic tools, and pre-contact and colonial period ceramics. An expanding inventory of over 130 cave sites has already influenced existing models of cave development on Barbados and in the broader region. This integrated approach indicates that the limited number (<2%) of recorded cave sites in the archaeological literature underestimates the extent and significance of karst on the island, including its pivotal role in defining a complex Barbadian cultural sequence, from prehistoric migration and settlement, through the Euro-colonial expansion, to the present day.

La Barbade est géologiquement et géographiquement distincte de la chaîne d'îles volcaniques de l'arc des Petites Antilles. Sa géographie et géomorphologie (côtières et continentales) unique, ont été des facteurs clés dans la détermination de l'utilisation des terres archéologiques, historiques et modernes. Le recensement archéologique de la surface de la Barbade a identifiés de nombreux sites culturels clés qu'ils ont fournie des informations importantes sur les modèles culturel pré- et post- contact, cependant, l'examen détaillé des grottes comme dépositaires archéologiques et historiques importantes a été relativement limité avec seulement deux sites rupestres associés étudies de façon officielles. Des travaux récents permettent une compréhension plus complète des processus spéléo-génétique qui ont façonné les reliefs karstiques complexes de la Barbade en plus de l'inventaire des ressources culturelles dans les sites rupestres clés, la documentation de l'art rupestre, les coquillages, les outils non-lithique et pré-contact et les céramiques de l'époque coloniale. Un inventaire de plus de 130 sites troglodytiques a déjà influencé les modèles existants de développement des grottes de la Barbade et dans la région plus élargie. Cette approche intégrée indique que le nombre limité (<2 %) des sites rupestres enregistrées dans la littérature archéologique sous-estime l'ampleur et l'importance du karst littoral sur l'île, y compris son rôle central dans la définition d'une séquence culturelle Barbadienne complexe, de migration et de peuplement préhistorique, grâce à l'expansion euro-coloniale à nos jours.

Barbados es geológicamente y geográficamente distinta a la cadena de islas volcánicas del arco de las Antillas Menores. Su geografía y geomorfología (tanto de costa y del interior) única han sido factores clave en la determinación de los usos arqueológicos , históricos y modernos del suelo. La arqueología de superficie de Barbados ha documentado numerosos sitios culturales importantes que han resultado en importantes conocimientos sobre los patrones de pre - y post - contacto cultural. Sin embargo, el estudio detallado de las cuevas como importantes depósitos arqueológicos e históricos ha sido relativamente limitado con sólo dos sitios de cuevas asociadas con excavaciones formales. Trabajo de campo reciente integra una comprensión más completa de los procesos espeleogenéticos que han conformado las complejas formaciones kársticas de Barbados con inventarios de recursos culturales en los sitios de cuevas clave, la documentación de arte rupestre , material de conchas, herramientas no-líticas y cerámica pre-contacto y del periodo colonial. Un inventario en expansión de más de 130 sitios de cuevas ya ha influido en los modelos existentes de desarrollo de cuevas en Barbados y en la región más amplia. Este enfoque integrado indica que el número limitado (< 2 %) de los sitios rupestres grabados en la literatura arqueológica subestima el alcance y la importancia del carso costero en la isla, incluyendo su papel fundamental en la definición de una secuencia cultural compleja de Barbados, de la migración y el asentamiento prehistórico, a través de la expansión Euro-colonial, hasta nuestros días.

The Physical Landscape of Barbados

Karst landscapes encompass more than half of the total land area in the Caribbean (Day 2010). These complex terrains have shaped the accompanying regional biodiversity, human settlement patterns and land uses throughout history to the present day (Figueredo 2011). Caves, a seminal component of karst landscapes, are widely recognized as important repositories of cultural and biological materials, preserving long term and contemporary records of human activity, climate change and biodiversity (Lace and Mylroie 2013; Willig et al 2010) and the caves of Barbados are no exception. Geological studies of the complex landscapes, including petroleum and watershed resources, across Barbados are extensive and in-depth compared to specific studies of the island cave resources (Humphrey 1997; Machel 1999; Speed et al. 2013). Similar to this disparity in geological fieldwork, archaeological evaluations of cave sites on Barbados have been sporadic and limited to a select few while surface sites, including pre-contact settlements, shell middens and colonial period sites, have been more thoroughly documented.

A comprehensive examination of the caves and karst of Barbados was initiated in 2009, utilizing detailed cave surveys in conjunction with geophysical and cultural resource assessments designed to integrate an in-depth understanding of speleogenesis in this unique karstic island environment with a more complete accounting of the associated archaeological significance of these shoreline and paleoshoreline landforms (Baily and Parkington 1988). This study examines previously reported geoarchaeological studies of caves on Barbados in comparison to patterns of prehistoric, historic and contemporary human uses of cave sites documented in the course of current coastal karst field research.

Geophysical Setting

Barbados is the easternmost frontier of the Caribbean islands (13°10N, 59°32W), located 150 km due east of the lower arc of the Lesser Antilles chain and flanked by the Caribbean Sea and the Atlantic Ocean (Figure 1A). Over 4750 km east of its Atlantic shores lies the west African coast. The island surface, 34 km long and 23 km wide, spans 431 km^2 and is encircled by 97 km of contemporary coastline and an extensive series of paleoshorelines exhibiting diverse geomorphologies, including significant karst landforms (Fermor 1973; Kambesis and Machel 2013).

Geologic Overview of Barbados

The broader Caribbean region is an extensive marine and terrestrial landscape forged from a complex sequence of geologic processes including plate tectonics, volcanism, changing sea levels and carbonate deposition. The majority of the carbonate islands (and associated karst) are located in the Greater Antilles while islands within the Lesser Antilles are composed primarily volcanic structures with comparatively limited carbonate exposures (and thus limited karst development) (Day, 2009). In stark contrast to the volcanic islands of the Lesser Antilles Arc to the west, Barbados is formed primarily of sedimentary rock on an emergent crest of an accretionary prism rising out of the Barbados Ridge which is formed in a subduction zone shaped by complex interactions between the Caribbean, North American and South American plates.

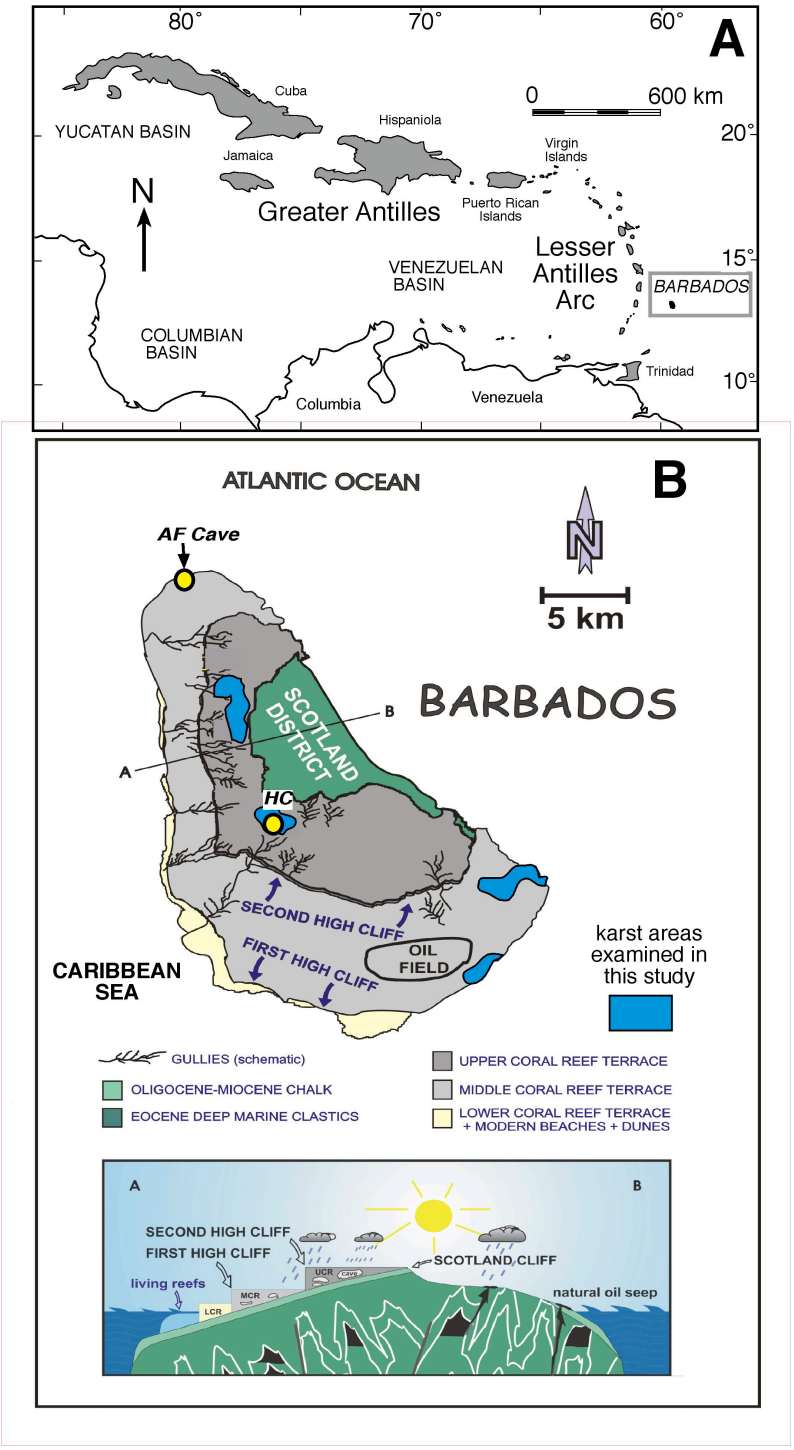


Figure 1. A) Regional setting and Barbados location. Adapted from Fink, 1968. B) Geologic overview of marine terrace development on Barbados. Approximate locations of Animal Flower Cave and Harrison's Cave (HC) and archaeologically significant karst areas examined in this study are also noted (modified from Machel, 1999).

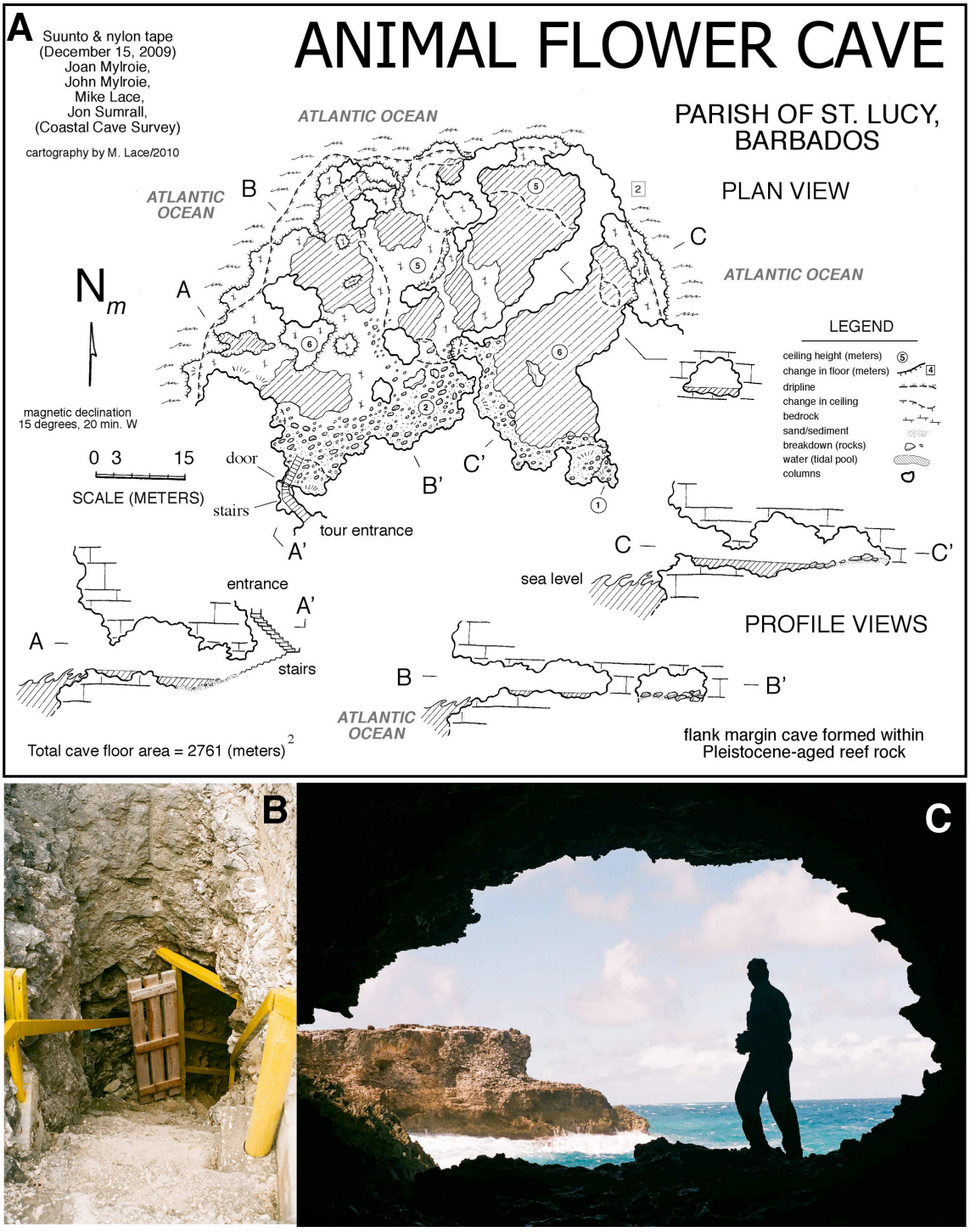


Figure 2. A) Map of Animal Flower Cave. B) Anthropogenically-modified inland cave entrance. C) Natural cliffside entrance.

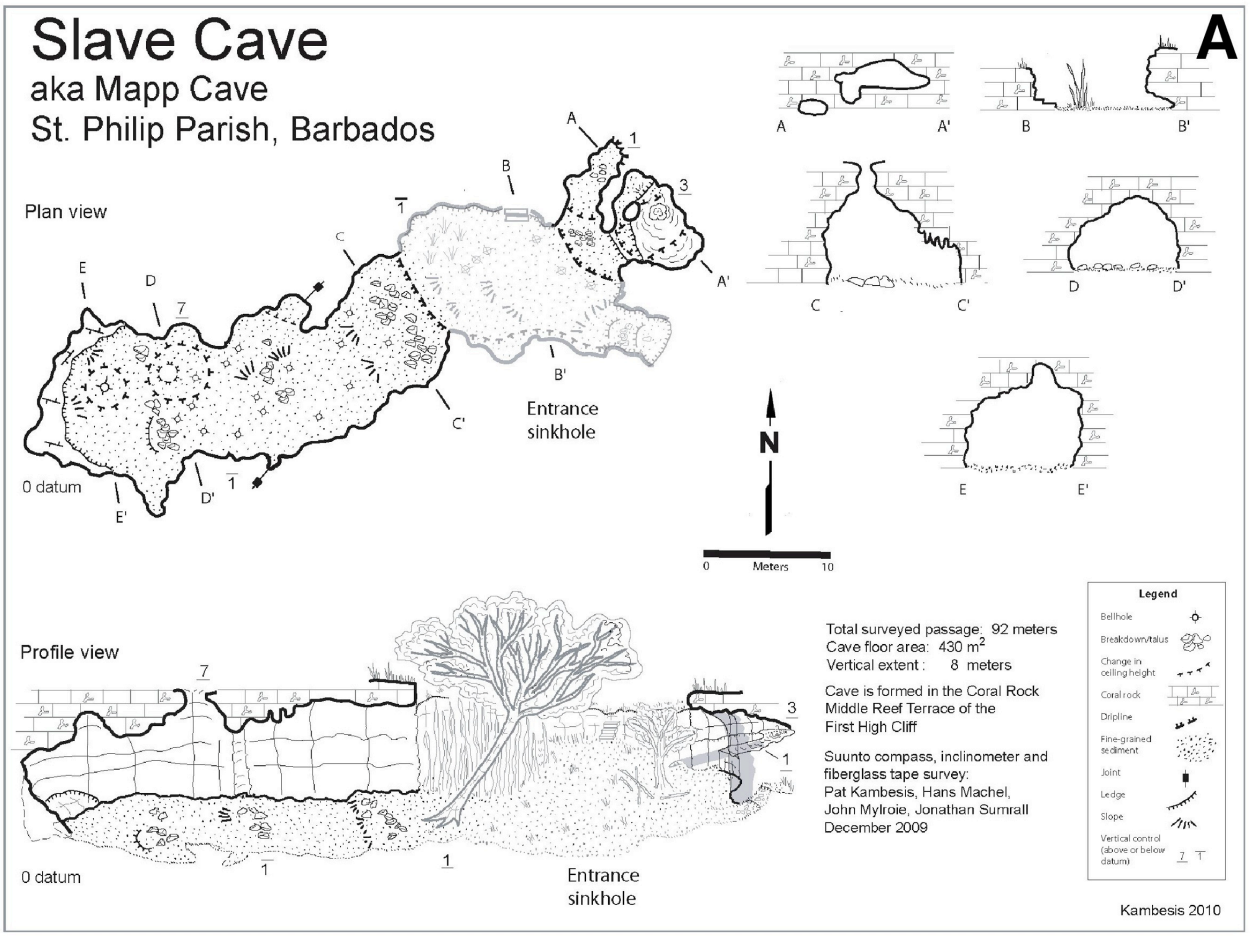
The island has experienced long-term episodic tectonic activity with estimated uplift rates for the island varying up to 0.4 m/ky (Humphrey 1997). The non-carbonate island core is overlain by a series of well-defined, uplifted carbonate reef terraces of Pleistocene age that form a well-preserved physical record of past sea level changes (Figure 1B) (Machel 2012b; Speed et al. 2013). The majority of these intensely karstic terraces display diverse expressions of cave development with examples documented in nearly all of the island's 11 parishes.

Structurally, Barbados conforms to a "composite carbonate island" setting according to the Carbonate Island Karst Model (CIKM) (Mylroie and Mylroie 2007), meaning it is an exposed non-carbonate island core overlain with carbonate rock. As in many other littoral settings, this carbonate island structure provided an environment suitable for coastal cave development – many of its caves harboring well-preserved, complex coral facies and passage morphologies consistent with dissolution processes associated with a freshwater lens. The island also harbors landforms consistent with traditional inland karst models that can be compared to karst in continental settings. These include complex karstic watersheds (Huang 2007) with dense sinkhole distribution, networks of branching solutional valleys and hydrologically dynamic subterranean conduits such as extensive stream caves (Machel et al. 2012a).

The ecological setting of the island, forged from its geographic position, geomorphology and climate, has influenced its comparative biodiversity, for example, its limited number of endemic bat species – six in all (Willig et al. 2010; Peck 1981). Similarly, the unique geography of Barbados would influence associated human migration and settlement patterns while its distinctive geology would shape pre-contact subsistence strategies (Drewet 1991b; Wing 1993) as well as historic and contemporary uses of its littoral landscapes (Loftfield 2001; Stoffle 2007). The non-volcanic origin of the island platform, for example, influenced prehistoric natural materials utilization. Implements were typically made from shell material rather than volcanic rock readily available on islands in the volcanic Lesser Antilles Arc, thus distinguishing natively-produced from introduced lithic tools from other areas.

Cave Development on Barbados

The complex karst landforms of Barbados include a range of structures evolved from the interplay of multiple karst (dissolutional) and pseudokarst (erosional) processes, including void development (cave genesis) resulting from phreatic dissolution, littoral erosion and cliff retreat (Kambesis and Machel 2013). Caves in Barbados are also found in a range of lithologies associated with current shoreline and paleoshoreline structures (associated with past interglacial sea level stillstands). Caves have been identified in coastal exposures of dolomitic chalks as well as abundant examples present in all uplifted limestone terraces that cover the majority of the island surfaces and span over 300 meters of elevation. Observed cave types vary in terms of their speleogenic origins and include fluvial (stream conduit) caves, sea caves, talus caves, a limited number of man-made cavities, fissure caves, flank margin caves and hybrid caves (those modified by secondary processes) documented to date (Machel et al. 2012a). Some of these structures would serve multiple purposes (utilitarian and ceremonial) to successive Barbadian cultures.



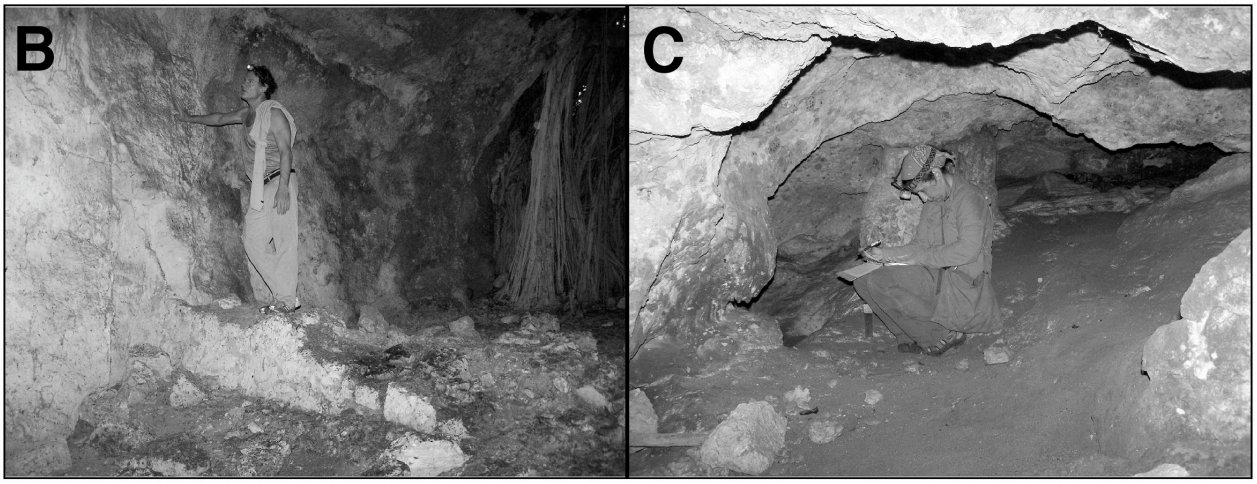


Figure 3. A) Map of Mapps Cave (aka Slave Cave) B) cave passage with slave-era brick wall remnant at subject's feet. C) Interior cave perimeter morphology.

The Cultural Landscape of Barbados

Pre-Contact Period

Rouse (1992) structured the cultural sequence in the region into four distinct periods, within the context of sequential migrations: Lithic (5000-3000 B.C.), Archaic (3000-200 B.C.), Ceramic (200 B.C.- A.D. 1500) and Historic (>A.D. 1500). While Lithic sites have only been identified in the northern islands, with the exception of Trinidad, Archaic sites in the Lesser Antilles are present but few in comparison to the Greater Antilles (Keegan 1994), potentially reflecting distinct migration/settlement patterns and/or simple explorational bias. Archaic Amerindian migrations to Barbados ["*Ichirouganiam*" to the Island Carib (Hulme and Whitehead 1992)] date back several thousand years. Compared to other migration routes across the Lesser Antilles chain, this involved no small feat of navigation by skilled mariners in open canoes against prevailing currents into the open sea (Fitzpatrick 2013). Successive cultural periods unfolded with the late pre-contact periods better studied to date, traditionally referred to as Saladoid (200 B.C.-650 A.D.), Troumassoid (A.D. 650 -1100) and Suazoid (A.D. 1100 -1500) (Rouse 1992).

Early archaeological surveys of Barbados confirmed cultural materials dating back only as far as 300 B.C. to A.D. 1 but did not exclude the possibility of an earlier archaic presence (Drewet 1991a). Some suggested that evidence of such an archaic cultural presence on the island may have been lost due to centuries of widespread commercial cultivation and development that has significantly altered much of the island's physical landscape. Recent dating of excavated marine shell material, however, suggests an archaic human presence on Barbados dating back to 2700-2300 B.C. based on calibrated dating of shell artifacts and associated materials (Fitzpatrick 2011) from the complex Heywoods site excavated by Drewet (2006). Examples of pre-contact petroglyphs are found at a single cave site (no surface sites have yet been documented) on Barbados and are loosely attributed to the late Ceramic (Suazan Troumassoid) period; although, as seen elsewhere in the region, confirmatory dating evidence is lacking for rock art (Farmer 2005).

The pre-contact cultural sequence on Barbados has primarily been defined in part by seriation of excavated ceramic materials within the context of intact assemblages in comparison to broader trends in the Caribbean (Rouse 1992). According to the Rousian model, earlier archaic migrations through the Lesser Antilles were proposed to have bypassed those islands that supposedly did not offer suitable resources, such as mountainous terrain with well-developed forest cover. Recent theories, however, suggest that prehistoric migration and settlement strategies relied more on a composite island platform structure that included not only the emergent landscape but the insular marine resources as well (Fitzpatrick and Keegan 2007; Keegan et al. 2008). Active volcanism within the Lesser Antilles may have also contributed to migration patterns (Fitzpatrick 2013). Recovered cultural remnants of prehistoric occupation of Barbados consist of assemblages of worked shell material, tools, ceramics and rock art in the form of petroglyphs (Drewet 1991a; 1991b).

Pre-contact cultural uses of cave sites in Barbados, as in many coastal areas, may have been generally opportunistic, such as availability of fresh water and marine food sources to suitable habitation or shelter sites, and/or specifically influenced by ceremonial

or ritual criteria. Archaeologically significant sites are found in fluvial, talus and flank margin cave structures within all three principal reef terraces on the island. Not surprisingly, evidence of cultural use of Barbadian caves frequently coincides with long-term bat roosts within the same structure. Bats played an important symbolic role in pre-contact Caribbean mythologies and ceremonial activities (Rodriguez-Duran 2002) and were represented in Barbadian adornos of the period (Drewet 1993b). The presence of such fauna at ritual cave sites could be argued to have influenced the criteria of ritual site selection. What is clear, however, is that cave sites used by the early inhabitants of the island were often used again in the colonial slave period, demonstrating sequential cultural cave use as documented in many other island settings in the Caribbean region.

Prior to European arrival, the native inhabitants (the *Island Caribs* - a problematic ethnonym applied by early European explorers) had supposedly abandoned their settlements on Barbados. Whether the so-called "*Caribs*" represented a distinct pre-contact culture that displaced or assimilated earlier populations on Barbados and other islands within the Lesser Antilles, as per Rouse (1992), or whether they represent a divergent cultural entity that evolved from Arawak populations remains a point of debate tempered by a range of perspectives, which is discussed in detail in Keegan's three part series (1994, 1996, 2000) and more recently in Lenik (2012).

The Post-Contact Period

In 1536, the Portuguese are thought to have given the island the name "*Los Barbados*" (or "*the bearded ones*") after the numerous fig trees displaying curtains of aerial roots, which apparently resembled beards. However, no Portuguese colonization of the island occurred at that time. British colonists subsequently arrived in 1627, initially focusing on tobacco and cotton but quickly establishing a large-scale agriculture system, including numerous sugar plantations to support rum, refined sugar and molasses production, which relied on African slave labor. The distinctive geographic position of Barbados also played an important role in the colonial settlement period as the island was comparatively spared the effects of contentious economic and strategic expansion by multiple competing European interests of the period throughout the Lesser and Greater Antilles. In contrast to other colonial settlements in the Caribbean, some of which repeatedly changed hands, Barbados remained a British colony.

While no "maroon-type" settlements are recorded on Barbados, Barbadian caves offered sanctuary to runaway slaves as similarly demonstrated on other karstic islands throughout the Caribbean (Handler 1997; Price 1996) and locally noted by Ligon, "These caves are very frequent on the island, and of several dimensions, some small, some extremely large and capacious. The run-away Negroes, often shelter themselves in these coverts …" (Ligon 1657:55).

A slave revolt occurred in 1816, also known as the Bussa Rebellion and the largest recorded uprising in Barbados history, but slavery was not banned by the British Empire until 1834. Politically, Barbados remained a British possession until it formed a politically independent nation in 1966. Culturally, Barbados remains a complex fusion of European and African influences.

Early Cave Exploration, Geological Reconnaissance and Archeological Fieldwork

Though regional archaeology has been more thoroughly established (Fitzpatrick 2004; Wilson 2007), elements of Barbados prehistory still remain undefined, particularly with respect to Archaic settlements, including transitional and ceramic periods (Boomert 1987; Bullen 1968b; Drewet 1993b; 2000; Taylor 1983). Cave exploration has and continues to provide archaeological studies in the region and beyond with the necessary physical context for examining patterns of cultural uses of karst landscapes in detail and this remains true on Barbados.

Records of cave exploration of Barbados date back to the post contact period where abundant caves were noted by European settlers, such as Ligon after his arrival in 1647 (Ligon 1657). Certain coastal caves were well known to the early European colonists and subsequent visitors to the island. Animal Flower Cave (Figure 2A), for example, was named by English explorers after the sea anemonies found in the saltwater pools near the seaward cliff entrances that open to the surging Atlantic Ocean (Figure 2C). The following description of the site was enclosed in a letter by the Reverend Griffiths:

> … At the north end of the island of Barbadoes, in St. Lucy's Parish, is a Cave about 14 feet long and 11 wide: Its Bottom is a Bason always full of transparent Sea-water, its greatest Depth about Three Feet: In this Bason there is Stone of about Four Feet long, and Three in Breadth, always covered with Water. From small Holes in the Sides of this Stone, at different Depths under Water, appear in Full bloom, at all times of the Year, several seemingly fine radiated yellow Flowers, with thick-set distinct else that came within Two or Three inches of Them, would in an instant close all their Leaves together, and the flower, stalk and all, would shrink back into the Stone..." [Hughes 1743:1].

Easel offered a more accurate description of the cave as, "… spacious, irregular, and divided into several compartments by the rocky supports of the roof, and is lighted up by as many openings, or mouths, all of which look upon the sea…" (Easel 1840:156). The cave was originally accessed by a dangerous climb down the seaward cliff face. The current inland cave entrance, likely a small natural skylight originally, would later be enlarged and modified in 1912 to accommodate a stone stairway and the cave opened as a modern tourist attraction that remains operational today (Figure 2B).

Early narrative accounts of archaeological sites also date back to the colonial period. Some cave sites were described as harboring artifacts, such as the "Indian Castle" in St. Peter's Parish, initially described by the Reverend G. Hughes in 1750 and later by Schomburgk:

> …it is of some extent, and entirely protected by the overshelving rock against wind and rain. In the neighborhood is a reservoir of water, partly natural, partly excavated called the 'Indian Pond'. The soil is here clayey, and it is conjectured by Hughes that the indians made their earthenware of it." [Schomburgk 1848: 238].

Chester also described excavations at sites the local inhabitants called "*indian*

caves" in three separate parishes (see also Figure 12C). A site in St, Michael's Parish, for example: " the cave presented the features of a room 30 ft. in length by 12 ft. in breadth, forming niches." (Chester 1870: 151).

Natural caves were also found to be repositories of abundant deposits of pre-contact tool made of shell, as described by Forte:

> The 'Carib chisels', as they are called in this island, are obtained from different parts, and the greater portion of them lie on or near the surface of the soil. Those I sent home were taken, with about 100 more, from a cave, and were found 6 or 8 inches below the surface. The cave is 350 feet above the sea level, and is situated at a distance of 2 miles from the sea: it is about 40 feet in length and 20 feet in breadth. It is entered below the side of a cliff, about 50 feet high, and with greater difficulty from above. … I found the remains of different shells, principally conch shells, in the same cave. No doubt the place had been the workshop of the Caribs, or of the people, whomever they were, who made the chisels, and this would account for the number of these instruments, and the quantity of broken shells. [Forte 1881:2]

These historical narratives varied widely in quality (Maycock 1830; Spencer 1902), ranging from seminal works defining the initial framework of geology on the island (Jukes-Brown and Harrison 1891) to accounts claiming the island was actually a continental remnant of Atlantis (Guppy 1911). Nineteenth century geologic reconnaissance included limited cave exploration in select sites, such as Harrison's Cave and Cole's Cave (Schomburgk 1848). Professional archeological excavations and assessments focused on the prehistoric periods of Barbados and began in the early 20th century with early site inspections from 1902 through subsequent surface excavations by Fewkes and others (Fewkes 1914; 1915; 1922).

Modern archaeology on Barbados has also focused primarily on surface sites as opposed to cave sites with several studies focusing on the historical archaeology and culture of the slave plantation period (Handler 1983b; Shuler 2011). In addition to periodic rescue archaeology assessments (Hackenberger 1991), more systematic archaeological surveys were conducted from 1985-1987 by Drewet and Harris (1991) and later supported by Drewet (2000) and Farmer (2008). Building on earlier works (Bullen 1968b), these systematic approaches attempted to broaden the scope and depth of field research with multi-disciplinary analyses associated with cultural resources across the island, effectively shaping modern Barbadian archaeology.

Well excavations also intersected fluvial caves as freshwater conduits, such as Harrison's Cave. Modern exploration initially focused on Harrison's Cave when Ole Sorenson, a Danish civil engineer, was contracted to assess the cave as a potential tourist attraction in 1970. A portion of the cave (the most extensive documented on Barbados to date) was extensively modified and opened to tourism by electric tram that continues to operate today in what is now the primary tourist attraction on the island with walls formed by the coralline limestone rock. In depth the cave is about 6 ft. All round the walls are a series of rounded arches

(Gurnee 1978). Later field exploration by Russell and Jeanne Gurnee further examined a limited selection of additional caves across the island (Gurnee and Gurnee 1991) but the true scope and complexity of cave development on Barbados remained incompletely defined.

During the development of Harrison's Cave visitors center, excavations revealed an abundant collection of pre-contact cultural materials, some of which is currently used in interpretive displays for the visiting public. Formal archaeological excavations of cave sites, however, have been and remain limited (Lange and Handler 1980; Drewet 1997; Mouer and Smith 2001) but, as the following examples demonstrate, the potential for identifying additional cave sites displaying multi-cultural period uses on Barbados is significant.

Defining Cultural Cave Sites on Barbados

The following caves emerged from the ongoing island-wide cave and karst inventory as significant cultural sites following detailed survey/mapping, using standard protocols (Palmer 2007) and geological and site preservation assessments in conjunction with photodocumentation and resource inventories. Cave morphologies were defined by site photography and detailed cave maps generated from the described fieldwork – each method providing complementary information to the spatial definition of each site. Site locations are listed in Figure 1B for the well known, commercial caves as well as karst areas on the island examined in this communication but specific locations for more sensitive sites have been omitted. Local cave names are included where known and where their inclusion did not place the site at increased risk for disturbance. All documentation was non-destructive and absolutely no collection performed as all natural and cultural materials were photographed and left *in situ*. Preliminary cave site evaluations documenting culturally significant materials were designed to preserve any archaeological and historical context to be complemented by formal excavations by future investigators.

Site B01SP. Mapps Cave (aka Slave Cave)

Site description: Initially, the cave morphology was generally compared to that of the cenotes of the Yucatan (Lange and Handler 1980). Recent examination of the cave structure supports a model of episodic freshwater lens dissolution of this uplifted marine terrace to explain its origins (Figure 3A-C) (Kambesis and Machel 2013). This flank margin cave has two segments floored with sediment throughout – the longer of which (~30 meters) has a SW trend averaging 7 meters wide by 5-6 meters in height - formed within Pleistocene-aged reef rock situated several kilometers from the current shoreline. Distinct fracture trends (198 degrees) and several bellholes (cylindrical cavities in the cave ceiling) were noted. The upper cave segment is reached by climbing one meter up to ledge leading into a 7 meter wide by 1 meter tall chamber with a partition on its west side while the lower cave segment trends northeast 5 meters to a breakdown choke with some air flow noted.

Cultural significance. The Mapps structure is one of the few recorded archaeological cave sites on Barbados (Lange and Handler 1980; Mouer and Smith 2001) with formal excavations. Cave sediments of the main chamber were correlated with those from an adjacent field, revealing historic and pre-contact period ceramics as well as marine shell harvesting, consisting primarily of Queen conch (*Strombus gigas)* along with West Indian Top shell (*Cittarium pica*), in addition to assemblages of vertebrate animal

remains. The nearest marine shell source is located several kilometers from the site. Pre-contact ceramics excavated by Lange and Handler (1980) were all identified as Suazan Troumassoid (A.D. 1000-1500) and proposed to be associated with Carib occupation of the site.

Additional colonial period materials were also found (with no clear delineation from "Amerindian" ceramics), suggesting a repeated sequence of cave use, consistent with local reports that the cave had also been used as a temporary slave imprisonment site (hence the local site name of "Slave Cave"). Man-made shoring was also observed at the northern cave wall was ascribed to post contact brickwork (Figure 3B) and metal bars over the skylight entrance as reported by Gurnee (1991). Smith (2008) invoked an anthropological perspective of colonial period use of the site, theorizing that slave occupation of Mapps Cave during the plantation era could have contributed to revolutionary planning prior to the 1816 uprising.

Site B02SJ. Springhead Cave (aka Matchstick Cave)

Site description. Springhead Cave is a paleo-stream conduit that trends to the northeast from its principal entrance. The cave is formed within the Pleistocene carbonate of the first high cliff, situated several kilometers from the nearest modern shoreline. There is an upstream and downstream entrance and two skylights, or vertical collapse openings, along its intervening length (Figure 4). The principal entrance is in an actively subsiding 5 by 6 meter sinkhole, leading into a lateral passage – 5 to 6 meters in height with large stalactites at or near the dripline (Figure 5). The cave passage continues through a large chamber (20 meter long by 8 meter wide) floored with breakdown talus and sediment composed of soil and bat guano. The cave ends in a decorated alcove also floored with guano, sediment, and abundant flowstone speleothems. A contemporary 4-meter long ladder provides access to a short stretch of upper level and a steeply sloping ramp, which traverses twenty meters in a zig-zag pattern to a small secondary entrance sink. Two skylights are visible from this entrance as are additional small sinks with large trees and brush in the area. Total passage length (including the upper level ramp) is 240 meters.

The cave is a geologically significant structure as an example of complex and extensive fluvial cave development (one of only four such structures completely documented on Barbados to date) and a key archaeological site on Barbados. It is possible that there are other undiscovered segments as the overlying land is a sinkhole plain with large shallow sinks. There may be other small, deeper sinkholes that access other segments of paleo-stream passage, potentially harboring important cultural remnants as well.

Cultural significance. The principal entry chamber contains rock art, initially cited by Gurnee (1991) and Dubelaar (1995) and later reported in detail by Drewet (1997) in conjunction with excavations of adjacent sediments. Consistent with these previous reports, observed rock art was confined to distinct petroglyph panels in the twilight area of the principal entrance where a cursory cultural materials inventory and rock art panel condition assessments were compiled. Minimal contemporary debris and some historic ceramics were noted in the main entrance area in addition to a total of thirteen petroglyphs recorded within three distinct panels – some of which could have datable rock coatings suitable for contemporary analyses (Chippendale and Tacon 1998) although no such rock art dating has been

conducted on Barbados to date. The remainder of the cave was not completely assessed for additional cultural materials due to time constraints. The rock art consists of a range of simple to complex anthropomorphic forms with body elaboration in panel I while panels II and III harbor only simple anthropomorphic forms. Preferential use of speleothem surfaces was noted with images ranging from simple to complex anthropomorphic forms with a moderate degree of body elaboration. Dubelaar (1995) noted a total of 8 images: 5 anthropomorphic and 3 abstract, while Drewet (1997), later identified a total of 14 images during site visits in 1989 and 1993. Image recording in 1993, however, was limited to sketches with scale (panel I) and sketches drawn not to scale (panels II and III) while the site map only illustrated the main entrance area examined at the time. The author also noted accumulated anthropogenic damage to panel I in the intervening 1989-1993 period.

Two trench excavations were also conducted in 1993 (Drewet 1997) in sediments adjacent to panel I and panel II. Faunal remains of species endemic to the site (e.g., bat bones) were identified along with historic colonial period clay pipe stems and crockery (rim and body sherds) consistent with 18th century sugar pots and evidence of temporary use campfires. The authors concluded that a collapse event occurred in this historic period, resulting in significant enlargement of what had originally been a small entrance to the cave, suggesting that the site could have been a near dark zone environment during pre-contact use. Excavations were intended to provide a cultural context for the petroglyphs, however, none of the excavated materials provided a correlative pre-contact date for the rock art within the cave.

Goals for the recent examination of the site included a detailed survey and map (Figure 4) of the complete cave structure, photodocumentation (with scale) of petroglyph panels (Figures 6 and 7) and assessment of their condition, including evaluation of both anthropogenic (e.g., graffiti) and natural processes (e.g., root growth, lithobionts, rock flaking, pitting and fracturing of the associated rock surface) potentially affecting long term preservation of the panels (Table I). The rock art stability index (RASI) provides a numerical expression of the composite effects these natural and anthropogenic factors may exert on the long term preservation of the rock art panels (Dorn et al. 2008). A low number indicates greater potential for preservation while a high number indicates greater deterioration and a lesser long-term preservation potential. The three panels varied in their observed vulnerabilities, with natural processes of floral growth and faunal activity as well as geologic processes exerting the majority of the observed influences while anthropogenic factors contributed to impacts to the condition of panel I.

Biological significance. A steep slope leads out of the chamber into passage that average 5 meters in width and 3 meters in height. There are a series of breakout domes where bats were noted. Breakdown is common on the north side of the passage with a slope on the southeast side. The cave floor is covered with significant bat guano deposits of indeterminate depth and is home to many millipedes and likely other guanophilic fauna. A northeast trending side passage that contains a large bat population was also noted; survey of that segment was not completed to avoid disturbing the significant colony (Figure 4).

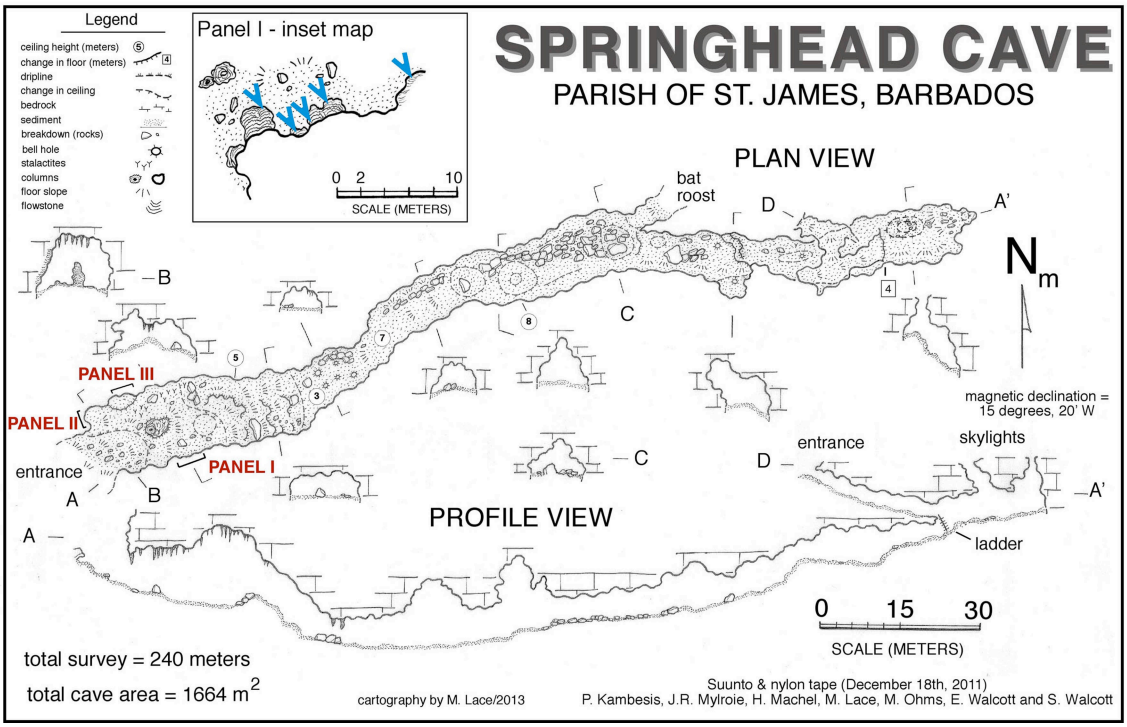


Figure 4. Springhead cave map. Note panel I-III locations and inset detail map of panel I with arrows illustrating spatial distribution of petroglyphs.

Table I. Springhead Cave rock art panel condition assessment

Panel	I	II	III	comments
setting	1	0	0	
weaknesses	7	1	2	
L. erosion	4	0	1	
S. erosion	9	4	4	
Rock coatings	1	-1	1	Progressive occlusion by sediment infill
Vandalism	Y	N	N	Scratched highlighting
[a]cummulative RASI score	22	5	8	

Rock art stability index (RASI) analysis as per Dorn (2008).

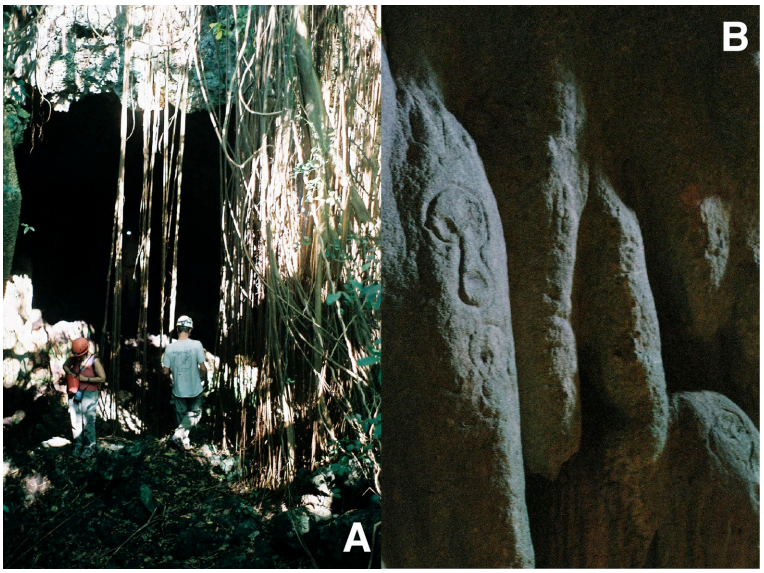


Figure 5. A) Main sinkhole entrance to Springhead cave. B) Rock art Panel I located inside entrance dripline photographed in natural light.

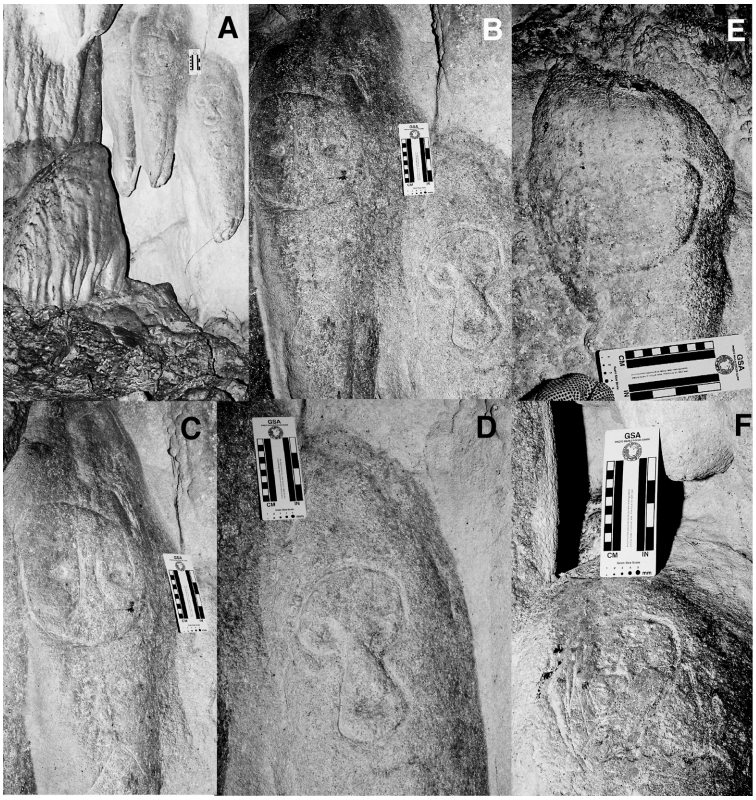


Figure 6. Springhead cave rock art Panel I. A) Physical context of panel within cave passage. B) Spatial distribution example. C, D and E) detail images of anthropomorphic petroglyphs. F) Detail of damage to petroglyph. Note 10 cm scale.

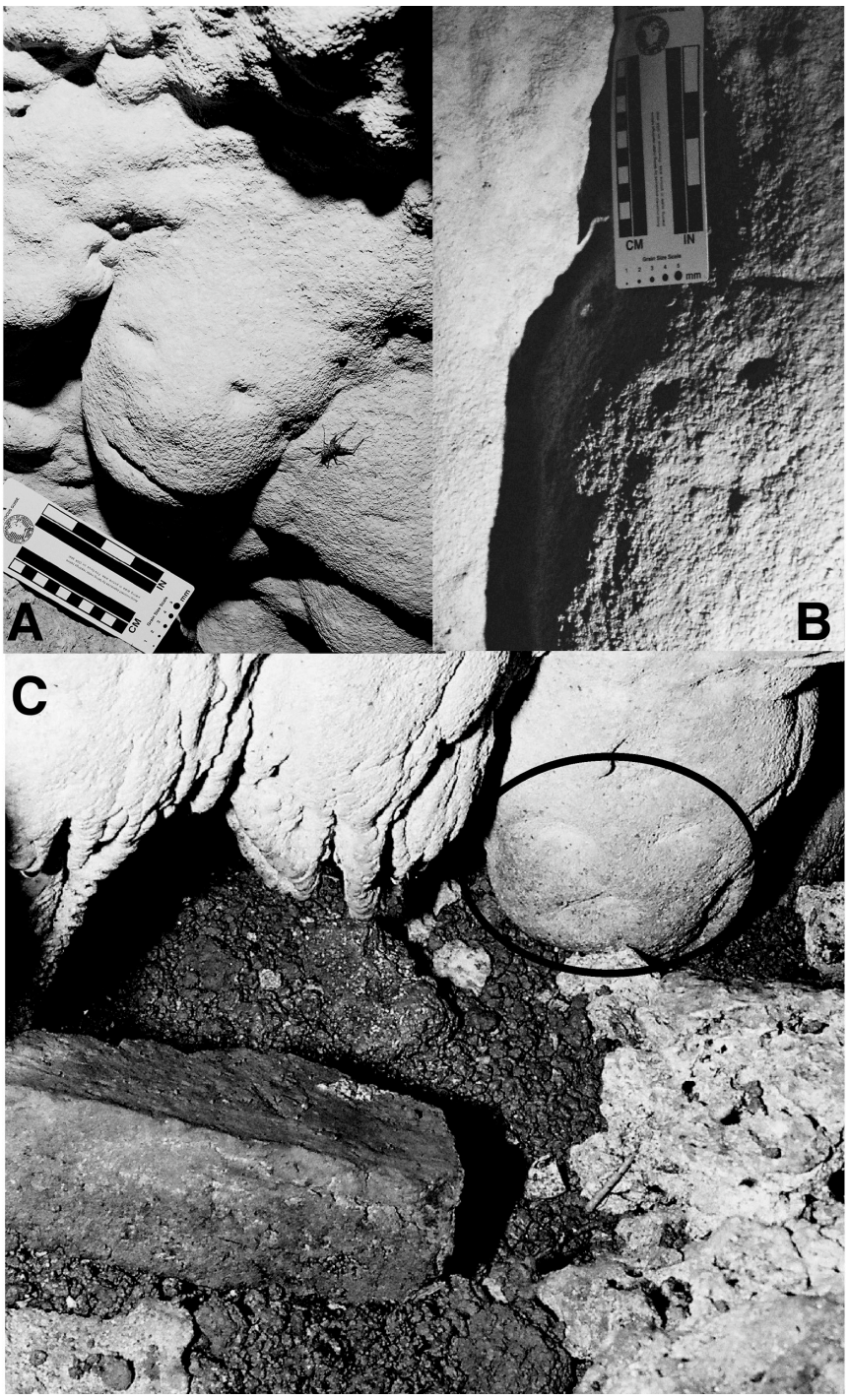


Figure 7. Rock art Panels II and III. A) anthropomorphic petroglyph carved in relief. B) incised simple anthropomorphic image. Note 10 cm scale. C) Petroglyph (encircled) in Panel II, note sediment and brick talus infill at its base.

Site Management. Access to the cave is well managed, restricted by the landowner to selected access permission and accompaniment by the property manager, both of whom are keenly aware of the site's archaeological value and importance to Barbadian cultural heritage and are highly motivated to continue its preservation. Land use is also well managed with an adjacent road, active stables and pastures but no commercial feed livestock production.

The entrance area continues to experience long-term slump events depositing infill consisting of rock and soil from a steeply sloped sinkhole. Sediment and talus have likely occluded some petroglyphs and cultural materials associated with panel II. Further, the progressive entrance enlargement and increased exposure to the surface environment has likely altered the microclimate significantly in the entry section; this would also contribute to long-term degradation of the panels in the form of increased exposure. The baseline assessment of the preservational status of the rock panels, recorded as the semi-quantitative RASI scores shown in Table I, can be integrated with future photomonitoring strategies and the detailed cave map (as a baseline tool) to monitor small and large scale changes in overall site integrity over time, as has been applied to other island settings in the region (Allen and Groom 2013).

Site B03SP. Unnamed cave

Site description. The main entry chamber of this flank margin cave is more than 40 meters wide and floored with massive breakdown overlain with sediment and modern trash (Figures 8A and 9). The cave is formed within the lowest emergent reef terrace near the modern shoreline with two sea caves located below the main chamber at the surf line within the entrance talus mound. A linear extension off the rear wall leads started as a sediment-floored stoopway that led into a large chamber and long-term bat roost as a massive mound of guano, more than 2 meters in depth), attested.

Cultural significance. The cave was known to European colonists as early as 1680. Historical traffic in the cave is evidenced by historic signatures adorning the interior walls, dating back to the late 1890s and extending to the mid-1940s (Figure 8B, C). Abundant pre-contact potsherds were also noted. The floor sediments have been repeatedly reworked – shifted and incised with runnels by repeated cycles of advancing/retreating storm surge, revealing pottery fragments on the surface. Coarse, undecorated potsherds were abundant and consistent with Troumassoid ceramics described in Mapps Cave and other surface excavations (Bullen 1968a; Harris 1991). The pottery remnants included some rim sherds with a simple finger indented patterns (Figure 10A-C) similar to those described elsewhere in the region (Bullen 1965). Some sherds were clearly derived from significant-sized, thick-walled ceramic vessels, including legless flat-based griddles typical of those used for preparing cultivated cassava (Keegan 2000) and consistent with other Troumassoid sites/surface excavations (Drewet and Harris 1991).

A single potential petroglyph was also noted on the right wall, two meters above the floor and partially overprinted with historical and extensive modern scratched graffiti (Figure 8B). It is unclear whether the incised patterns underlying the modern impact to the wall surface represents an authentic example of rock art as it is not smoothed by secondary abrasion and could represent a modern imitation of a common pre-contact rock art form. However, the correlative abundance of pre-contact sherds

with such a potential rock art example at the site is intriguing and requires more detailed analysis. The site is currently protected, to a degree, from casual human traffic and associated impact as current access to the site is technically difficult, requiring advanced exploration skills and appropriate safety equipment.

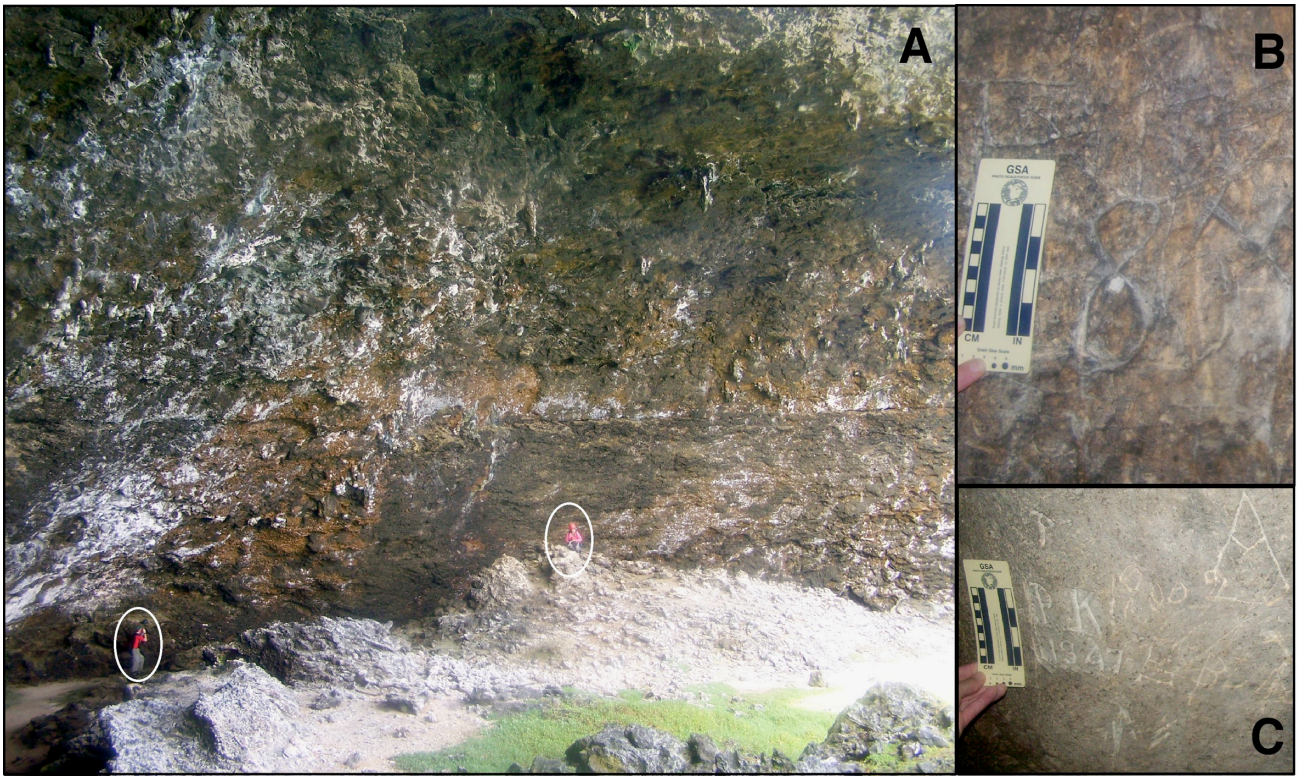


Figure 8. Site B03SP. A) Entry chamber (note explorers in white ovals for scale) B) wall engraving and C) historical graffiti in interior chamber (19th century and 1947 dates as examples).

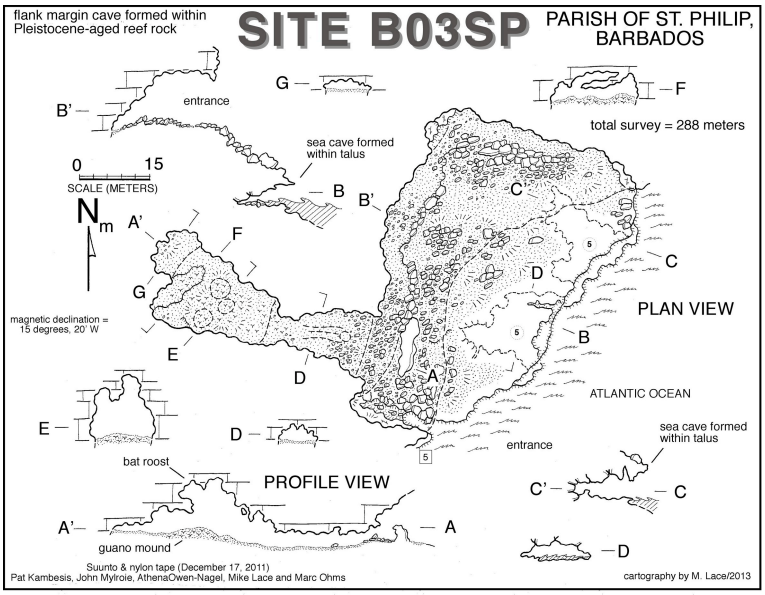


Figure 9. Map of Site B03SP

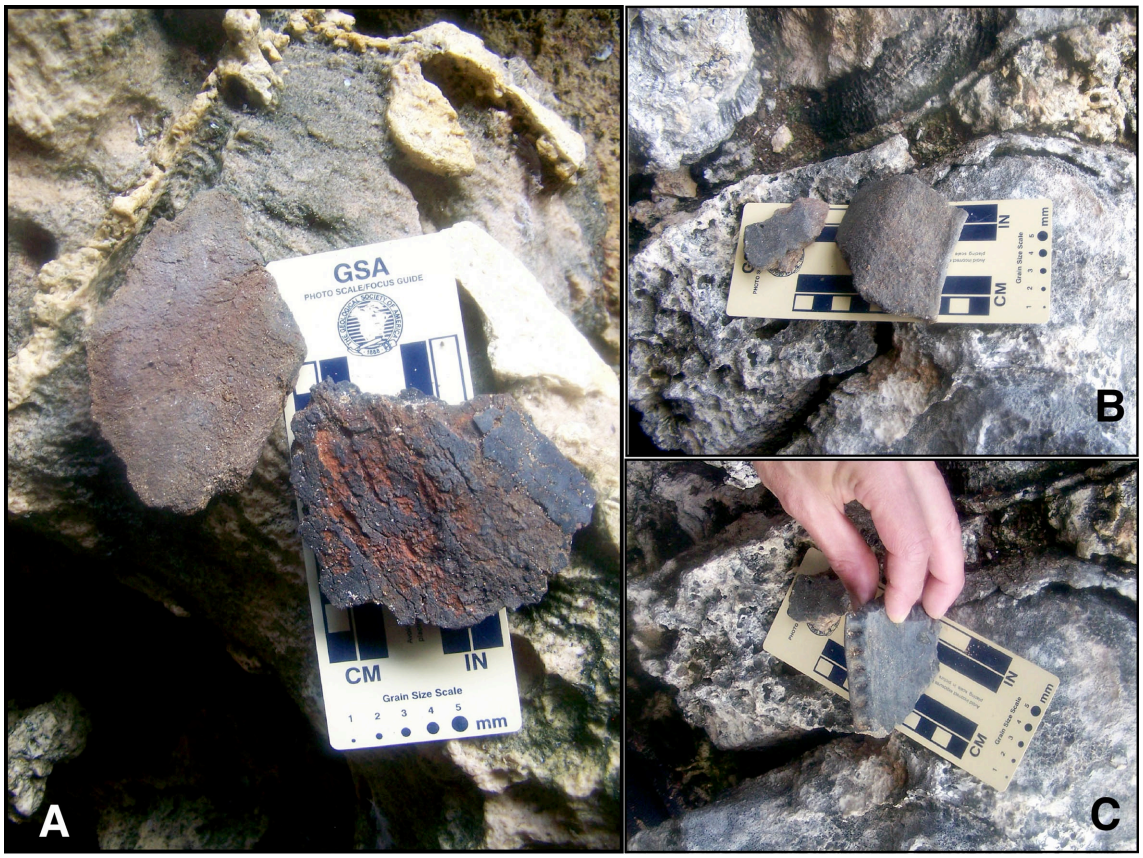


Figure 10. Cultural materials at site B03SP. Examples of A) body sherds and B) rimsherd with C) finger indentation ornamentation. Note 10 cm scale.

Site B04SP. Flowing Stone Cave

Site description. The cave is formed within the lowest emergent reef terrace associated with modern shoreline. Entrance to this flank margin cave is at a talus slope and the cave trends southeast for 40 meters along a sandy sediment floor (Figure 11A). Well-preserved flowstone speleothems (columns, stalagmites, stalactites) located on the southwest side of the passage. The cave terminates in a series of interior ramiform chambers.

Cultural significance. Pre-contact sherds (Figure 11B) and historic metal objects were found, documented and left *in situ* within the cave. The site is pristine and the cave sediments have been undisturbed except for storm surge near the entrance dripline and could potentially yield additional archaeological materials during formal excavation.

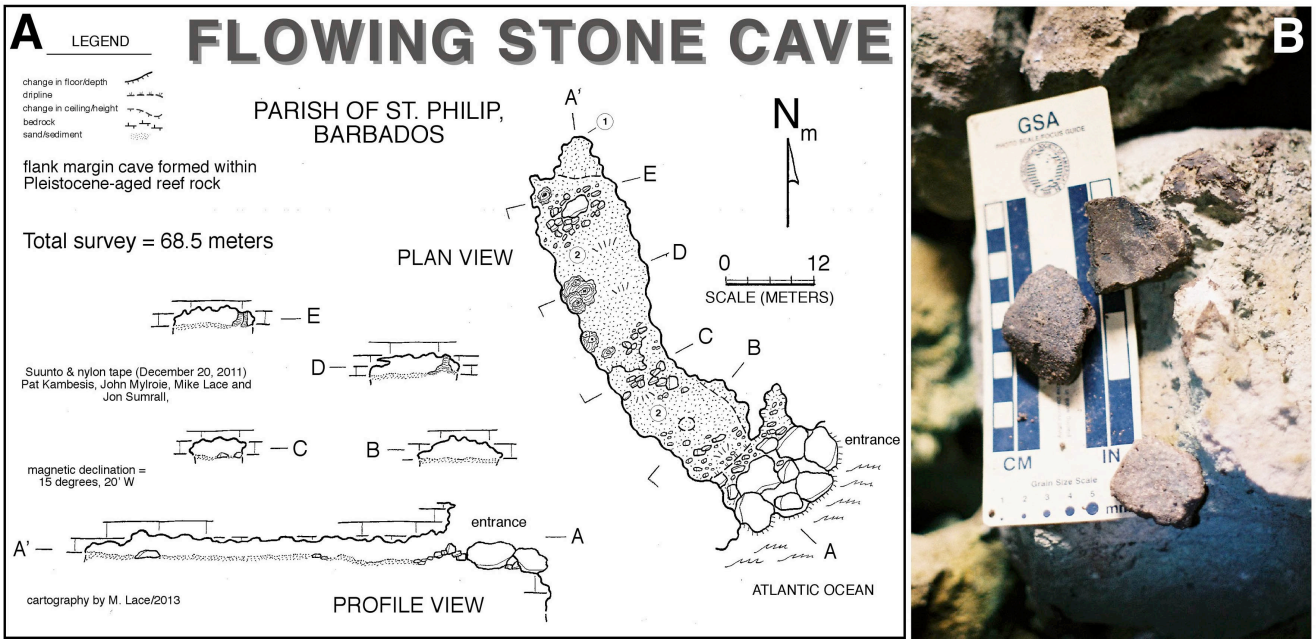


Figure 11. A) Map of Site B04SP (Flowing Stone Cave). B) Body sherds. Note 10 cm scale.

Site B05SP. Slave Quarters

Site description. The site is a historic, man-made chamber (called the slave quarters after local rumored use) – dug into the second high cliff limestone (Figure 12A,B). The structure was consistent with descriptions of similar excavated structures noted by the Reverend Chester in the late nineteenth century (Chester 1870) (Figure 12C). The intended purpose of the excavated chambers or subsequent uses remain unclear.

Figure 12. Slave Quarters. A) Entrance and B) excavated niches within structure. C) woodcut of excavated chambers described by Chester (1870) as: cave (no.III) on the Ararat Estate, Barbados. Reprinted from the Archaeological Journal.

Site description. The cave is formed within Pleistocene-aged reef rock of the 2nd high cliff, several kilometers from the nearest modern shoreline. Entrance is at a short talus slope, composed of soil, rock and modern refuse, that leads down to a sandy floor with sporadic breakdown piles. The cave trends southeast for approximately 40 meters with occasional flowstone speleothems (columns, stalagmites, stalactites) located primarily on the southwest side of the passage and terminates in a series of cuspate chambers. The cave is a seminal example of flank margin cave development on Barbados and perhaps the best-preserved, in terms of cave morphology and cultural remnants, visited so far with elaborate cuspate walls (Figure 13A) and numerous bedrock pillars – structural remnants of the dissolution process (Figure 13C). Prior to mapping the site, human access to the cave had been interrupted (for an undetermined period of time) by sediment infill/occlusion resulting from an entry sink collapse (Figure 13B).

Cultural significance. The survey documented abundant potsherds, pre-contact and historic, ceramics and tools scattered throughout the cave, well beyond simple migration of material along the entry sediment slope advance, indicating *in situ* placement deep within the cave. While the active entry slope subsidence and surface scatter throughout the cave preclude precise delineation of sequential deposition of associated cultural materials from post depositional mixing. Excavations of the undisturbed floor sediments are likely to be more definitive and yield additional archaeological materials.

We noted marine shell use (Figure 14A-B), pre-contact rim and base sherds (Figure 14C-D), potential tools (Figure 14D), clay pipe bowls, historic crockery remnants, and more modern human debris (Figure 15), consistent with the use of the sinkhole as a modern refuse pit . Clay pipes (Figure 15A-B) (also excavated from Mapps Cave and Springhead Cave) were frequently used during the slave period and more elaborate forms have been identified in Barbados (Handler 1983a; 2007). Though clay pipes have been associated with slave burials, no overt evidence suggests that the cave was used for human internments. Historical ceramics were consistent with the period forms described (Handler 2009). As in all cave sites examined, sherds, shell materials and historic ceramic, glass and metal objects were photodocumented and left *in situ*.

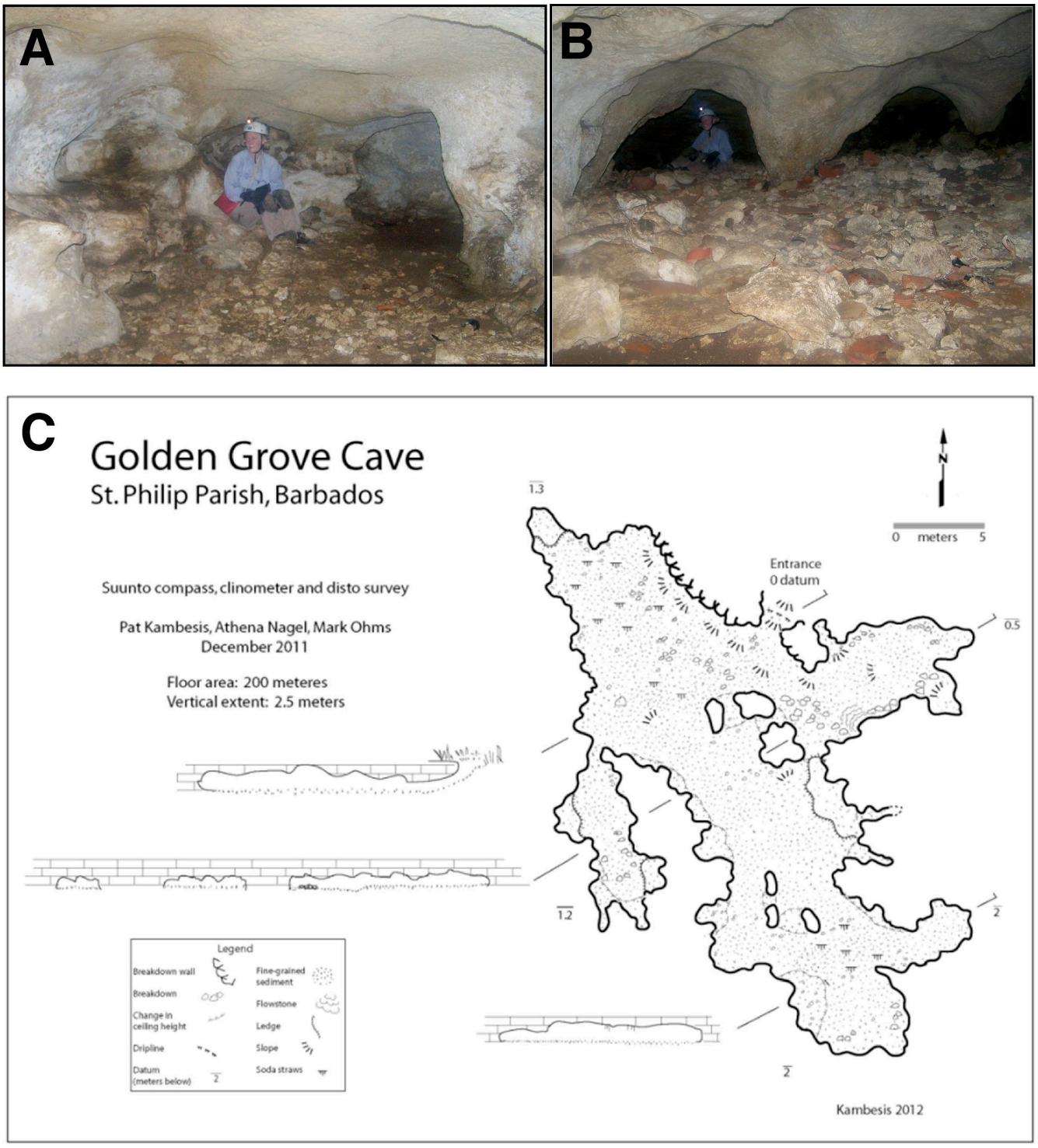


Figure 13. Cave Morphology and map of site B06SP A, B) Characteristic ramiform morphology of interior passage with widespread cultural material scatter. B) Cave map.

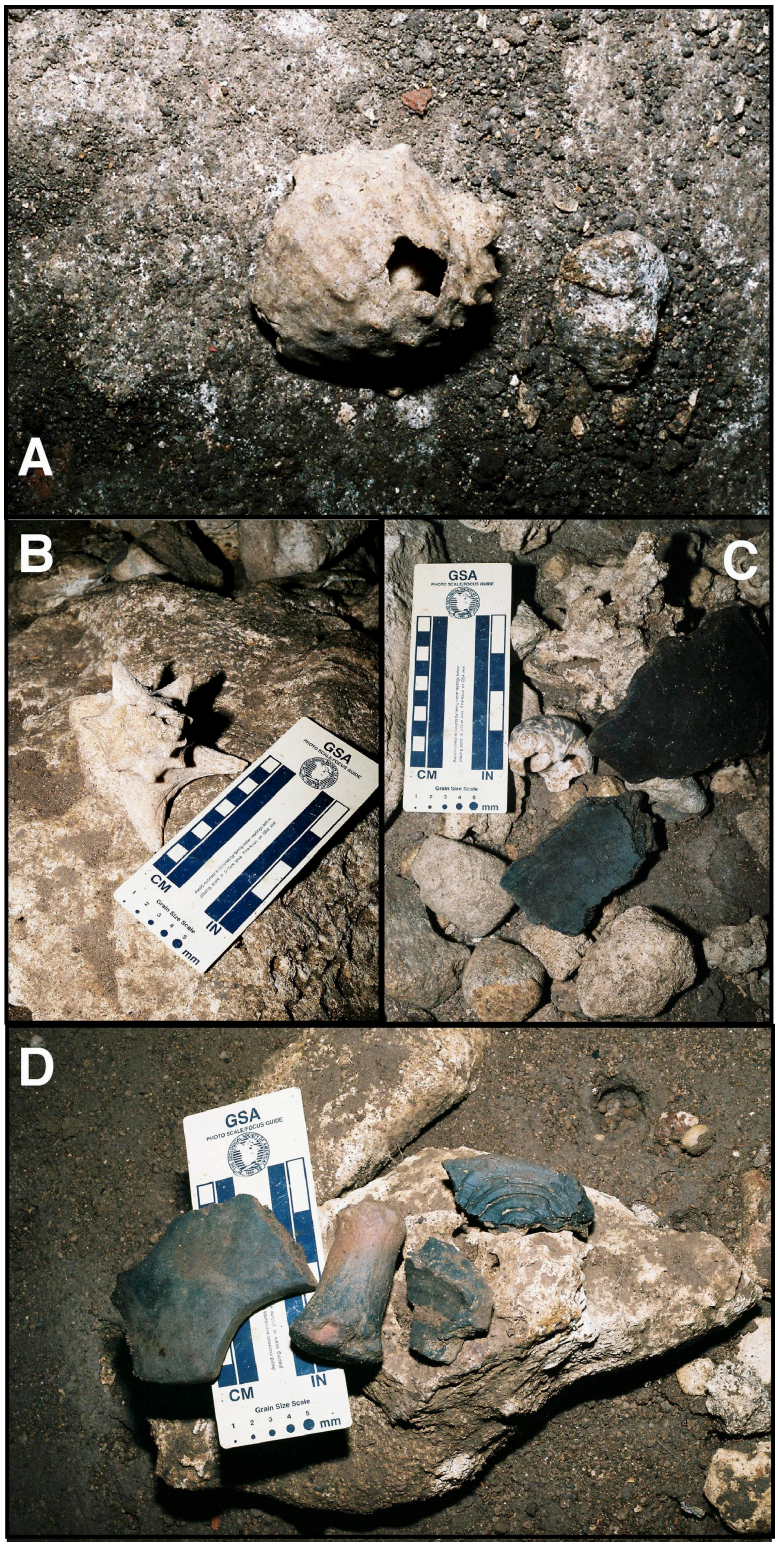


Figure 14. Golden Grove Cave (Site B06SP) pre-contact materials. A) Evidence of marine resource use: anthropogenic perforation of West Indian Top Shell to facilitate extraction of its contents. B) Harvesting of conch shells (Strombi). C) Coincident shell material and potsherds. D) Assemblage of rim sherd, base sherd and potential griddle leg.

Figure 15. Site B06SP historic artifacts. A, B) Crockery remnants and clay pipe bowls common to the Barbadian slave plantation period. C) Abundant historic crockery remnants, including D) rim sherd of a molasses drip jar (note 10 cm long light for scale).

Site B07SP. Mt. Brevatore Cave (aka Indian Castle)

Site description. The cave consists of a large linear flank margin chamber breached by cliff retreat at one end and breached along wall of gully along its side at multiple points (Figure 16A). It is a flank margin – a dissolutional void cave formed within Pleistocene-aged reef rock - either as a result of the gully confining the freshwater lens within the nose of the ridge or a preexisting chamber repeatedly breached by erosion of the enclosing ridge by cliff retreat and gully development.

Cultural significance. The site is historically known as the "*Indian Castle*" and examined by early amateur archaeologists in the colonial period (Hughes 1750; Schomburgk 1848), yielding some artifacts. Early accounts insisted that the structure was man-made. Fewkes (1915) argued at the time that it represented one of the only examples of aboriginal man-made caverns in the Antilles, though confirming evidence was lacking. Contemporary survey of the cave structure confirmed that the site is actually a natural cavern subsequently modified by man (Figure 16B), The cave is known among the locals and features some contemporary debris as well as mining historical artifacts, evidence of guano excavations and wall signatures in pencil dating to 1936.

Site B08SP. EP Cave

Site description. The talus cave consists of a single, bi-lobed chamber formed within a Pleistocene carbonate glide block resting on a dolomitic coastal slope (Figure 16C). Small potsherds (likely pre-contact) were noted within eroded sediments inside entrance dripline.

Modern Examples of Cave Use from Barbados

Contemporary use and modification of caves is also known in this setting, ranging from human habitation to small scale and large scale development as tourist attractions, for example, Animal Flower Cave (Figure 2A) and Harrison's Cave, respectively (Gurnee 1991). Commercial cave development, however, can introduce conflicting outcomes as site integrity can be compromised as a result of sometimes extensive modifications to the cave structure, as seen in historic modifications to portions of Harrison's Cave (Agramakova 2011). However, as economic resources, such sites can potentially attain broader zonal protections in terms of surrounding land use patterns and regulation. Similarly, as an interpretive resource, such sites offer a unique opportunity to educate the public on the complexity and fragility of such underground environments and the urgent need to preserve them in this and other karst settings.

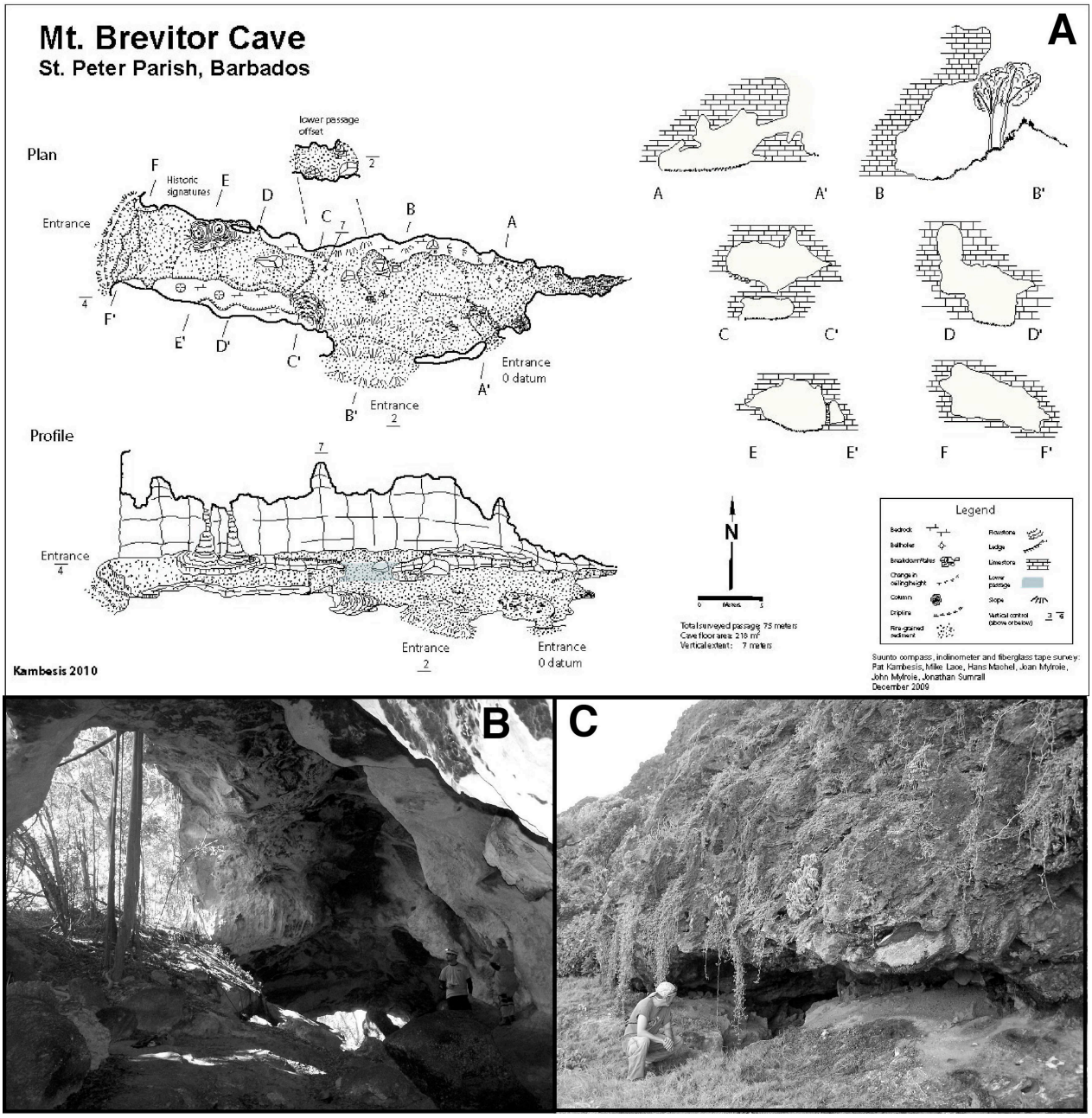


Figure 16. Mt. Brevitore Cave (Site B07SP) A) map and B) photo. C) EP Cave (site B008) photo.

Management and Preservation of Cultural Resources Associated with the Caves of Barbados

A total of seventy-five intact archaeological sites have been reported on Barbados. Rough estimates suggest that this total is half of what may have been available for study prior to long term and large-scale anthropogenic modification of the island's terrain (Farmer 2005).

Interestingly, in contrast to many other islands in the region, Barbados has only one cave with previously recorded rock art (Honychurch 2005). A second site (B03SP) has been tentatively identified with accompanying cultural materials to indirectly support its identification. Thus, 1 in 134 documented caves (<1%) on the island harbor pre-contact rock art; six out of this total (5%) harbor other archaeological materials. Though the sample size (i.e., the total number of cultural cave sites) remains too limited to quantitatively discern trends in human cave use in this setting, it does provide an important baseline from which future fieldwork can expand. Similarly, one cannot identify trends in human cave uses as a function of cave type unless the speleogenetic origins of the structure are correctly identified, applying modern theories of island cave and karst development as described in this communication.

Other islands across the Greater and Lesser Antilles display a broad range of rock art distributions (Dubelaar 1995; Hayward et al. 2009), where existing field studies permit accurate reporting of such trends. In conjunction with the absence of any recorded surface rock art sites, Barbados has a comparatively low rock art density, which may be a function of its unique pre-contact cultural sequence and the current field research status. Many anecdotal descriptions of archaeological materials associated with caves and shelters are present in historical narratives yet most have not been confirmed by thorough site analysis.

The current archaeological record associated with the caves of Barbados is limited to Ceramic-age and colonial period materials. This limitation likely represents a strong sampling bias as only one cave site (Mapps Cave; site B01SP) has yielded such evidence from formal excavation. Similarly, low rock art density recorded on Barbados, compared to other islands in the region, may indeed be a manifestation of a distinct cultural pattern but again we propose that is more likely the result of the same root explorational bias, as shown in the current communication which expands the total number of recorded cave sites of archaeological significance in the literature from 2 to 6. This total will likely change as additional cave sites are subjected to the same scrutiny described in this communication, just as the record of human activity and the cultural sequence on the island has been progressively revised in the course of continuing surface archaeology.

Overall Cave Site Preservation Status

Barbados is currently one of the most populated and developed islands in the Caribbean with an estimated 650 persons/km^2. Commercial and residential development on Barbadian karst carries potential risks not limited to cultural site integrity but, as demonstrated in Briton Hill (Kambesis and Machel 2013), also extends to fundamental geologic landform stabilities and associated risks to life and property. Current strategies, however, fail to incorporate a thorough karst assessment in commercial site selection (Kumar Dey et al. 2008). Concerns over site disturbance and preservation noted in earlier studies (Lange

and Handler 1980; Farmer 2005) are still relevant today as the remaining intact archaeological cave sites stand at significant risk from changing land use, climate change and geologic processes in a dynamically evolving landform. Current strategies designed to integrate Barbadian cultural site information from numerous sources into a composite database (Farmer 2008) can benefit from the inclusion of detailed cave surveys and resource inventories as outlined in this communication and consistent with established cultural resource and cave and karst management protocols in other settings (Jones et al. 2003; Lace 2012; Lee 1991). While preservation assessments of individual sites (such as rock art panels as shown in Table I) are of limited utility on island-wide and/or regional scales, they illustrate a site-specific methodology with a broader monitoring capability that can be adapted and modified to enhance future archaeological site assessments on a wider geographic scale. One can compare changes in site integrity with changes in the associated physical landscapes as a result of natural processes or changing anthropogenic land use patterns within such a GIS based model (Helmar et al. 2008). Furthermore, a numerical scale for site condition summaries in conjunction with karst landscape sustainability indices (Van Beynen et al. 2012) can be implemented across Barbados and in broader comparative studies.

The Barbados Caves Authority was established in 1977 and charged with preservation and development of such resources. Other compatible initiatives incorporate preservation of endemic biodiversity, including the six species of bats known on Barbados (Genoways et al. 2011; Grindal 2004), and their associated karst habitats within the context of both Coastal Zone Management and a National Biodiversity Strategy and Action plans enacted in 1998. Both cave geoarchaeology and cave biodiversity to a degree invoke comparable preservation and management goals and strategies, however, both require detailed and in depth inventories that define the distribution, abundance and complexity of resources associated with cave sites on Barbados.

Conclusions

The unique geographic and geologic settings of Barbados have strongly influenced its changing cultural landscape from its prehistory, through its colonial period and modern history. Evolving debates surrounding the interpretations of cultural migration and settlement patterns in the Lesser Antilles persist and extend well beyond the scope of this communication. Cave sites on Barbados may not resolve all of these controversies but may uniquely preserve associated chronologies of site use, as demonstrated in other locales (Goldberg and Sherwood 2006). We conclude that the limited number of archaeological cave sites on Barbados reported in the literature represents an explorational bias. Clearly, a thorough understanding of the geoarchaeology of Barbadian cave resources remains incomplete, requiring a systematic analysis of a more complete cultural site database. Caves must form an integral component of such a dataset. As demonstrated in this report, one critical tool forged from such a systematic approach is a detailed cave map to help define the geomorphology of the site within the context of human activities: archaeological, historical and modern. Such tools further define the spatial distribution of archaeological materials within the cave, potentially revealing broader patterns of cultural site use that might otherwise remain undefined.

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