Very Large Boulders on the Coast of Grand Cayman: The Effects of Giant Waves on Rocky Coastlines
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Very Large Boulders on the Coast of Grand Cayman: The Effects of Giant Waves on Rocky Coastlines

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ABSTRACT

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Two stretches of rocky coastline on Grand Cayman are characterized by boulders that are up to 5.5 m long, 3.4 m wide, and 2.3 m high (estimated to weigh as much as 40 tonnes). Clusters of boulders, which are irregularly distributed through the area, occur up to 100 m inland from the present-day shoreline. All of the boulders were derived from the microcrystalline dolostone of the Bluff Formation that forms the coastal terraces of these areas. The occurrence of sponge borings, *Lithophaga* borings, encrusting vermetid gastropods, and encrusting *Homotrema* on some boulders, however, shows that some must have been submerged in seawater prior to transportation to their present position. One boulder is also covered with *Astrangia solitaria.* Radiocarbon dating of this coral yielded an age of 1662 AD (1625 to 1688 AD at 68.3% confidence limits); an age that probably reflects the time when the coral was removed from its marine environment.

Analysis of the boulders suggests that they were transported to their present position by a giant wave(s) that swept across Grand Cayman approximately 330 years ago. Such waves moved some blocks, estimated to weigh 10 tonnes, up to 18 m vertically and 50 to 60 m horizontally. These boulders may have been moved by hurricane-generated waves or a tsunami that was triggered by an earthquake or slumping on submarine slopes. No wave of comparable power has affected the island since 1662.

ADDITIONAL INDEX WORDS: *Coastal profile, boulder rampart, boulder transport, blowhole, giant waves, hurricane waves, tsunamis.*

INTRODUCTION

Coastal areas on small, low-lying oceanic islands can be quickly and radically altered by giant storm waves or tsunami. Such effects are especially evident along coasts that have no offshore reefs to protect them. For example, boulder ramparts and sand and boulder beaches on Grand Cayman (Figure 1) are mute testimony to the power of hurricane-generated waves (RIGBY and ROBERTS, 1976). Similarly, many Pacific islands have large boulders on their reef flats that were derived from the front of the reef (*e.g.* BOURROUILH-LE JAN and TALANDIER, 1985; GUILCHER, 1988). There is, however, little information concerning the effect that giant waves have on the erosion of exposed rocky coastlines.

Two stretches of rocky coastline on Grand Cayman (Figure 1) are characterized by large boulders (estimated to weigh as much as 40 tonnes) that occur up to 100 m inland from the present-day shoreline. These boulders offer an ideal opportunity to examine the effect that severe sea conditions have on rocky coastlines. This is done by integrating the information available on the (1) morphology of the coastline, (2) morphology of the coastal terrace, (3) size and shape of the boulders, (4) distribution of the boulders, (5) composition of the boulders, and (6) age of the boulders. This information is used to suggest some of the mechanisms that may have been operative during the transportation of these boulders.

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GENERAL SETTING

Coastal features and deposits around Grand Cayman are controlled by the orientation of the coast relative to the dominant easterly winds and the presence or absence of an offshore reef (Figure 1). Thus, sheltered coasts are generally characterized by sandy beaches whereas exposed coasts have terraces formed of limestone or dolostone (Figure 1). Boulder ramparts and mixed sand and boulder beaches were formed by hurricanes that passed over Grand Cayman (Figure 1). The boulder ramparts, for example, are formed primarily of corals that were transported onshore during the 1931 and 1932 hurricanes (RIGBY and ROBERTS, 1976).

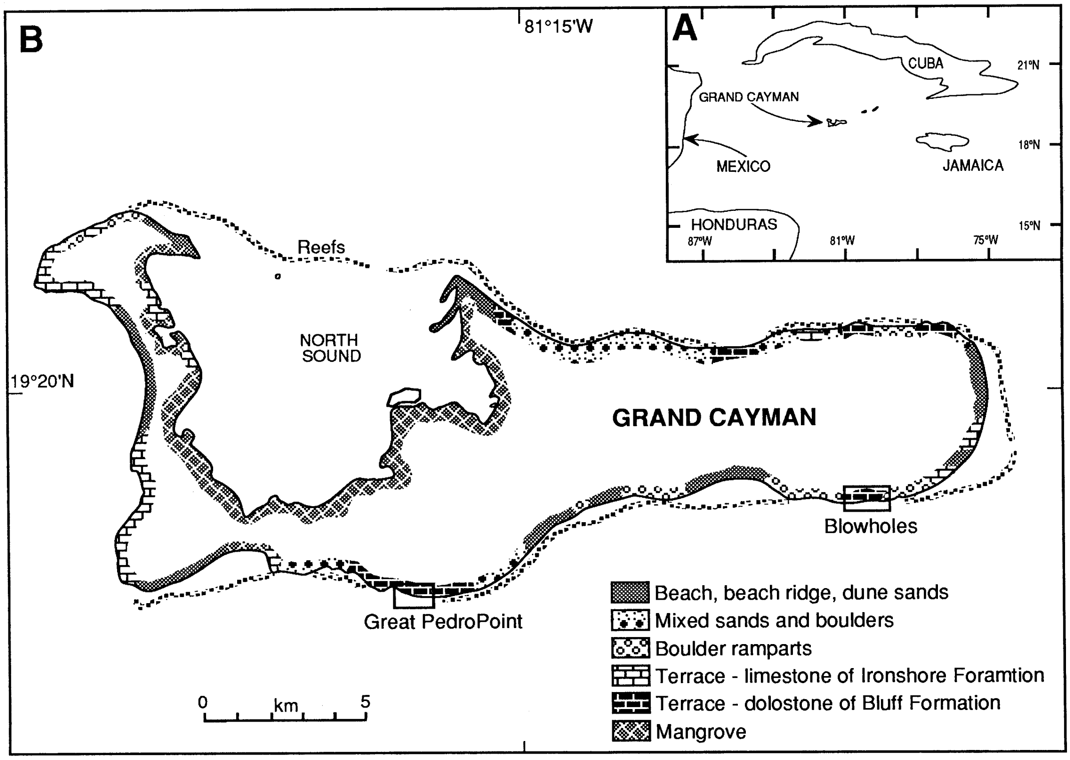

Figure 1. (A) Location of Grand Cayman in the northern Caribbean Sea. (B) Location of study areas at Blowholes and Great Pedro Point. The distribution of the various types of coastal landforms is modified from RIGBY and ROBERTS (1976: Text-Figure 13).

The areas around Blowholes and Pedro Castle on the south coast receive the full impact of onshore waves because there are no off-shore reefs to protect them. The Blowholes area (Figures 1 and 2) was used to determine the distribution of the boulders relative to the modern and Pleistocene (125,000 year old) shorelines, the age of the boulders, and the size range of the boulders. Although the objectives were similar in the area near Great Pedro Castle (Figures 1 and 3), greater emphasis was placed on determining the large scale distribution of the boulders, and the nature of weathering on the exposed coastal terrace.

BLOWHOLES

General Setting

Even on calm days the high-energy coast near Blowholes is characterized by roughwater conditions and waves breaking on the rocky shoreline send substantial amounts of spray onshore. The coastal terrace is formed of massive, microcrystalline dolostones that belong to the Cayman Member of the Bluff Formation (JONES and HUNTER, 1989). These strata, which dip at 5° to the west, contain numerous colonial corals (*Montastrea* and *Siderastrea*) up to 2 m in diameter and are cut by numerous joints (RIGBY and ROBERTS, 1976).

Coastal Profile

For convenience, the area between the coastline and the road is divided into the coastal zone and coastal terrace (Figures 2 and 4A). The coastal zone is characterized by steep cliffs that rise up to 4 m above sea level (Figure 4A). At sea level there are flat erosional platforms, extending 5 to 6 m in a seaward direction (Figure 4A), that are encrusted by vermetid gastropods, foraminifera, and algae.

The coastal terrace is divided into zones A and B by a break in slope that occurs 6 m asl (Figures 2 and 4A). The coincidence in the elevation of this slope break with a 6 m wavecut notch elsewhere on the island (JONES and HUNTER, 1990) suggests

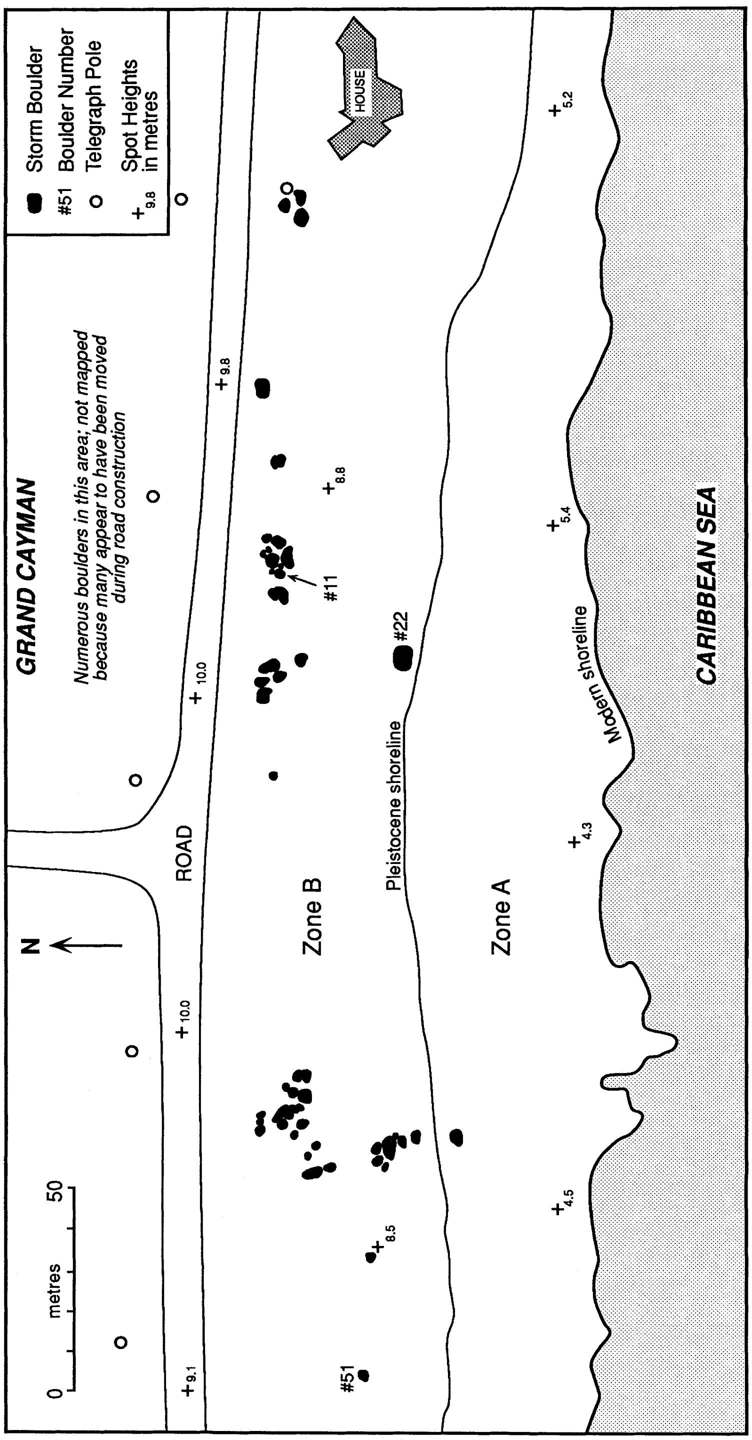

Figure 2. Detailed map of Blowholes area showing distribution of boulders relative to the modern and Pleistocene shoreline. The shape and size of the boulders is shown as accurately as possible on this scale of map. Some of the smaller boulders have been slightly enlarged in order to show their location. Boulder #11 is highlighted because it is bored by sponges and bivalves. Boulder #51 is highlighted because it is bored by sponges and bivalves, and encrusted with *Astrangia solitaria*. Spot heights taken from the 1:2,500 scale maps of the island.

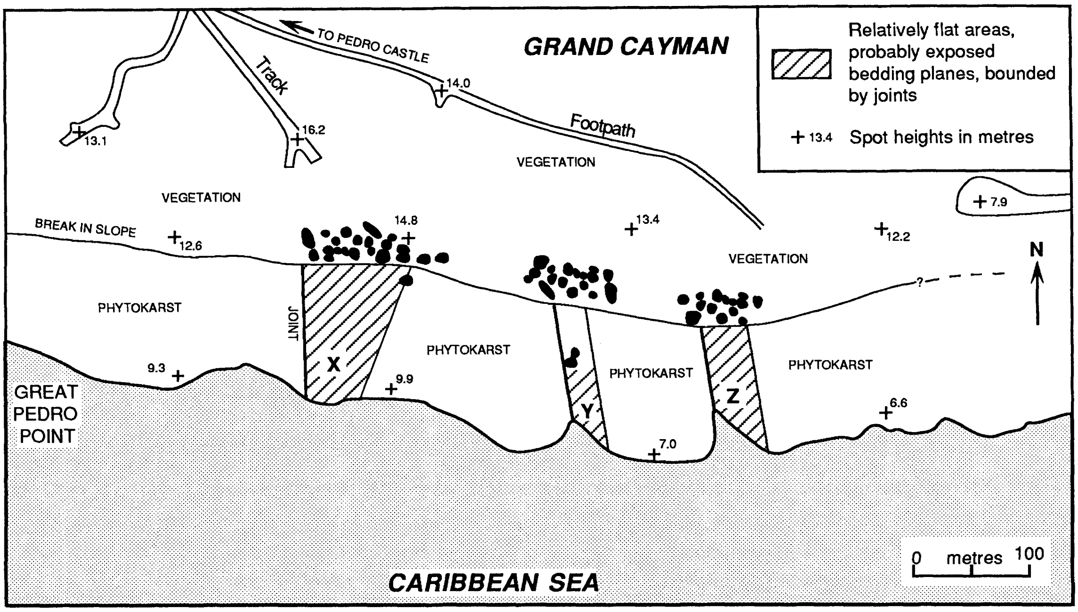

Figure 3. General map of the Great Pedro Point area showing distribution of boulders, position of break in slope, and occurrence of phytokarst and flat, exposed bedding planes on the coastal terrace. Areas X, Y, and Z are bounded by well-developed joints. In each case, the joint on the west side is wider and better developed than the joint on the east side. Spot heights taken from the 1:2,500 scale maps of the island.

that it marks the Late Pleistocene (125,000 years) shoreline (Figure 2).

Zone A, 30 to 45 m wide (Figures 2 and 4A), is characterized by rugged phytokarst that includes sharp pinnacles and ridges with up to 1.5 m relief. This style of weathering is similar to that developed on most exposed surfaces of the Bluff Formation (FOLK *et al.*, 1973; JONES, 1989). Throughout this zone, however, there are flat exposed bedding-planes that lack the ridges and pinnacles of the surrounding phytokarst. Such areas, bounded by joints, are up to 1.5 m below the general level of the terrace and cover areas up to 10 m by 10 m. Low-lying areas in zone A are commonly filled or partly filled with modern unconsolidated carbonate sands and coral heads that were probably washed onshore during recent storms.

Zone B (Figures 2 and 4A), landward of zone A, is characterized by phytokarst that is more subdued than that in zone A. This zone also has a thicker vegetation cover, probably because it is removed from the sea spray. Low-lying areas in this zone are covered by marine sands and/or freshwater gastropod shells.

Storm Boulders

Distribution

Of the 51 boulders mapped, 50 occurred in zone B (Figure 2). The single boulder in zone A occurs 5 m seaward of the break in slope that is considered to be the Pleistocene shoreline (Figure 2). The boulders are unevenly distributed through the area with clusters of boulders being separated by areas devoid of boulders (Figure 2).

Shape

Most boulders have a distinctly rectangular, box-like shape with a flat base (bedding plane) and flat sides (joint surfaces). On some blocks the flat base passes laterally into a smooth surface that gently curves upwards (Figure 5A). These surfaces, which are morphologically identical to the upper part of a wave-cut notch, always occur on the eastern end of the boulders.

Upper surfaces of the boulders are characterized by phytokarst with sharp angular ridges and pinnacles. Plants, which are common on these surfaces, root directly in the rock or in organic debris that has accumulated in the depressions.

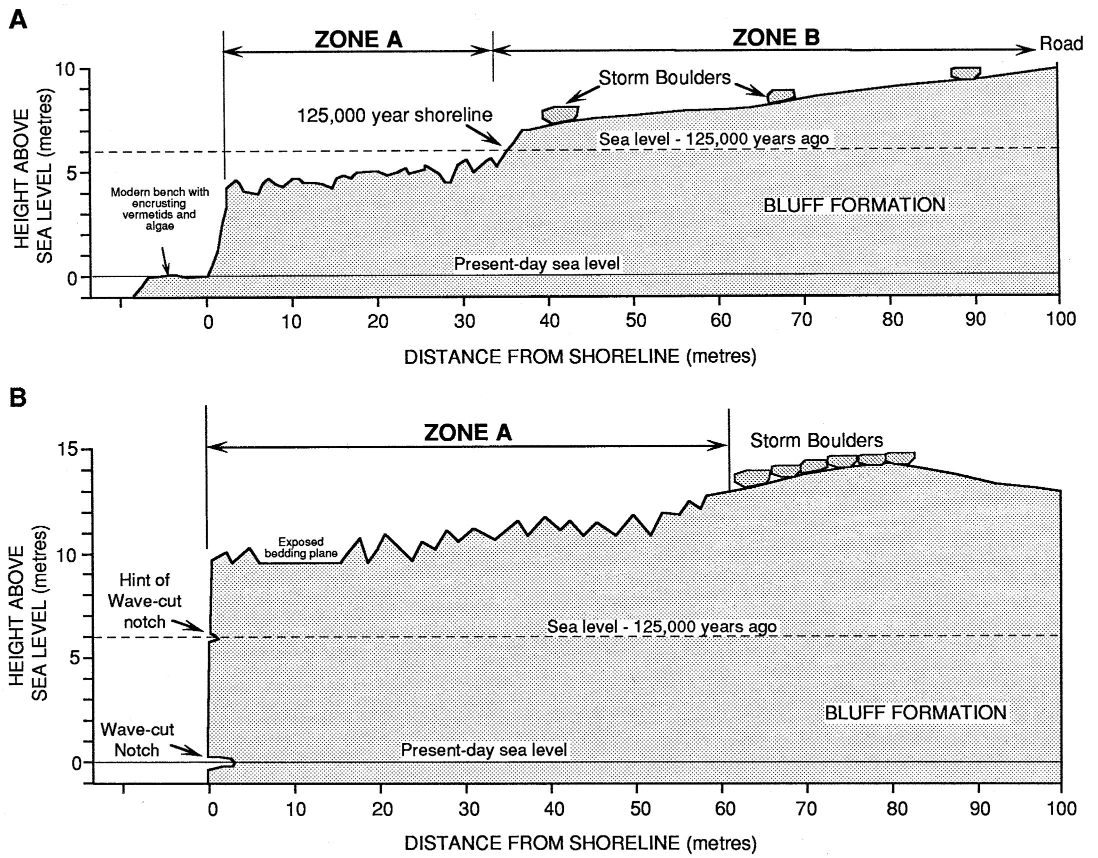

Figure 4. Schematic cross-section through the coastal areas at Blowholes (A) and Great Pedro Point (B) showing the nature of the coast, the general morphology of the coastal terrace (zone A) and the occurrence of the boulders in zone B, landward of the break in slope. The position of the Sangamon sea level at 6 m above present day sea level is taken from JONES and HUNTER (1990). Elevations taken from the 1:2,500 scale maps of the island.

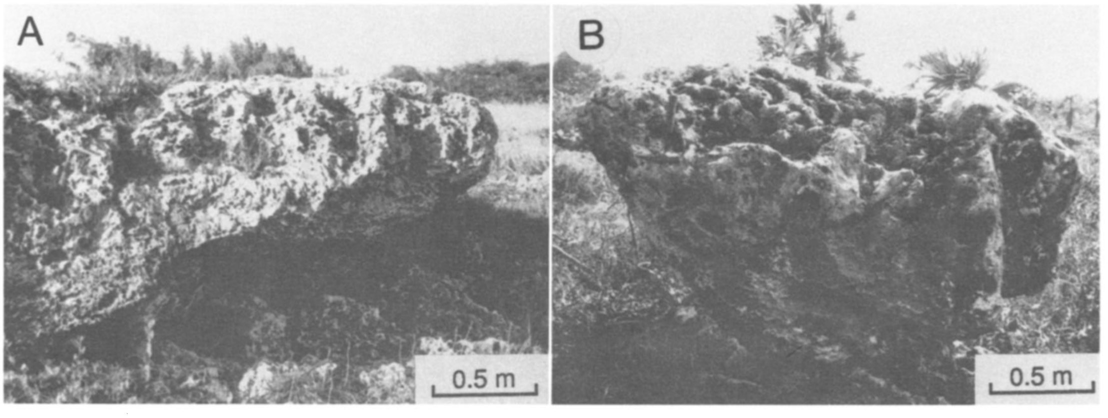

Figure 5. (A) View of east end of boulder #22 (Figure 2) showing wave-cut notch. This boulder, which is 5.5 m long, 2.8 m wide, and 1.5 m high, is the largest boulder in the area. (B) View of boulder #51 that has been bored by *Lithophaga* and *Cliona* and encrusted by vermetid gastropods and *Astrangia solitaria*.

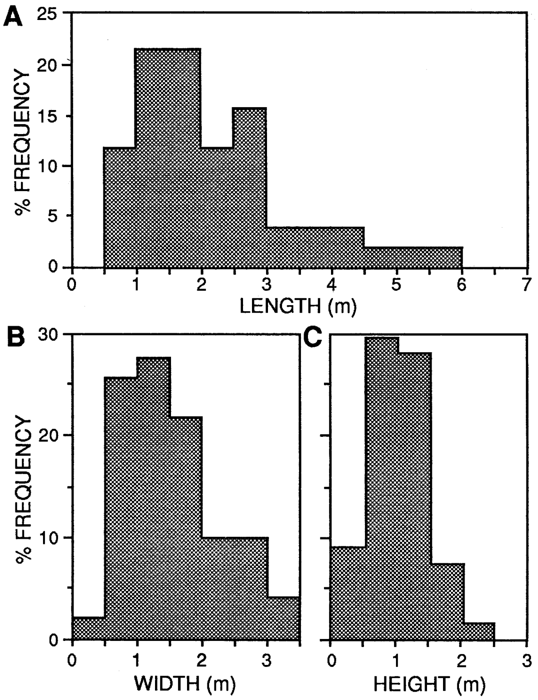

Figure 6. Histograms showing distributions for the length (A), width (B), and height (C) of boulders at Blowholes. Note that most of the boulders are less than 1.5 m high.

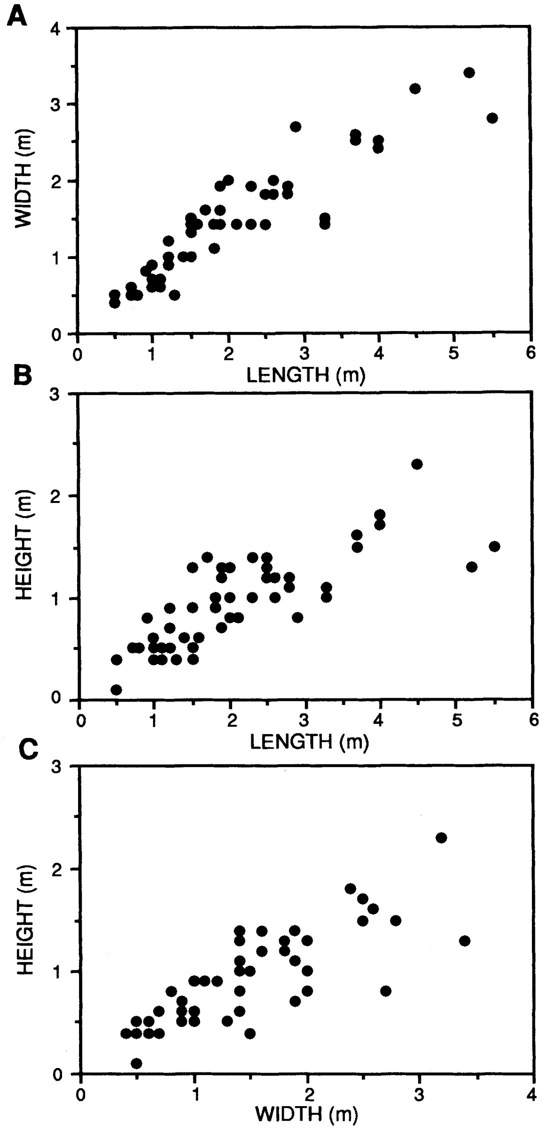

Figure 7. Bivariant graphs of length versus width (A), length versus height (B), and width versus height (C) for the boulders at Blowholes. Note high correlations between all parameters.

Size

The boulders are up to 5.5 m long, 3.4 m wide, and 2.3 m high (Figure 6). Most boulders are less than 1.5 m high (Figure 6). The largest boulder is 5.5 m long, 2.8 m wide, and 1.5 m high. The strong correlation between the length, width, and height of the boulders (Figure 7) suggests that they are genetically related.

Orientation

Twenty-six boulders have their long axis aligned east-west whereas 18 have their long axis aligned roughly north-south. The other 7 boulders have no orientation because their length and width are equal. Many boulders with a north-south orientation are resting on or against other boulders. It is possible that their movement, and hence their orientation, may have been impeded by previously deposited boulders.

Composition

Many of the microcrystalline dolostone boulders contain corals and rhodolites similar to those in the Cayman Member which forms the coastal terrace in this area. This indicates that all the boulders were derived locally from the coastal terrace.

Unusual Features

Two boulders have features that separate them from the others. Block #11 (Figure 5B) has been extensively bored by sponges (probably *Cliona*)

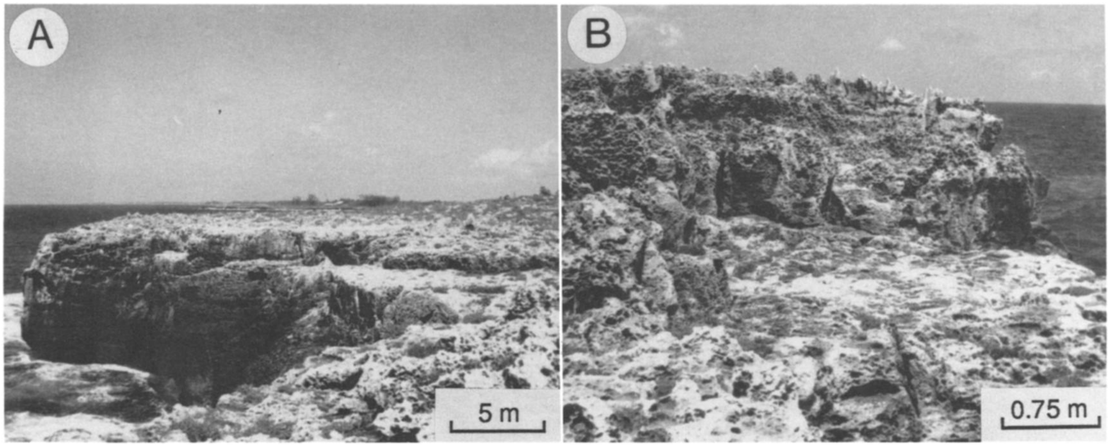

Figure 8. (A) General view of coastal terrace at Great Pedro Point (looking west). Some boulders, which occur inland of this area (Figure 3), were probably derived from the bed that was stripped from the lower lying area in the foreground. That area is bounded by a bedding plane and joints. Note wave-cut notch at present day sea level. (B) Close-up of area showing flat, exposed bedding plane that is below the level of the surrounding phytokarst.

and *Lithophaga*. In many cases the *Lithophaga* are still present in the borings which occur on all sides and the top of the boulders. Block #51, like block #11, has been extensively bored by sponges and *Lithophaga*. Locally, this block is also encrusted by *Homotrema*. The most spectacular feature, however, are the numerous well-preserved colonies of *Astrangia solitaria* that occur on the sides and top of the block. XRD analysis showed that these corals are formed entirely of aragonite.

Age

Astrangia solitaria from boulder #51, yielded an uncalibrated conventional radiocarbon age of 660 ± 50 years BP (corrected to a base of δ13C = -25%). Calibration against the dendro calibration curve gives an age of 1662 AD (1625 to 1688 AD at 68.3% confidence interval). If it is assumed that the corals were killed when this boulder was brought onshore, then the waves which moved these boulders occurred approximately 330 years ago.

GREAT PEDRO POINT

General Setting

This stretch of coastline (Figure 8), like that at Blowholes, is fully exposed to onshore waves because there is no offshore reef to protect it. As a result, this high-energy coastline is characterized by breaking waves and considerable amounts of sea spray.

Coastal Profile

This coastline is one of the most spectacular on Grand Cayman with vertical sea cliffs up to 10 m high (Figures 3 and 4B). The relief is accentuated because the cliff continues beneath sea level to depths of 8 to 10 m. Large angular blocks on the seafloor resulted from undercutting and collapse of the sea cliff in recent times. In most areas the present-day sea level is marked by a well-developed wave-cut notch (Figure 4B). From the coast at 10 m asl, the terrace rises gradually to about 15 m some 70 m inshore (Figures 3 and 4B). A break in slope, similar to that at Blowholes, occurs at about 14 m asl. The significance of this break in slope is not known.

The coastal terrace in this area is at an elevation above the 6 m level of the Pleistocene highstand (Jones and Hunter, 1990). Locally, the sea cliffs around Great Pedro Point have vaguely defined indentations at the +6 m level which may be remnants of the Pleistocene wave-cut notch. Thus, there is the suggestion that this coastal terrace remained above sea level during the last highstand.

The coastal terrace of this area is cut into microcrystalline dolostone that belongs to the Cayman Member (Figure 8). Their proximity to the

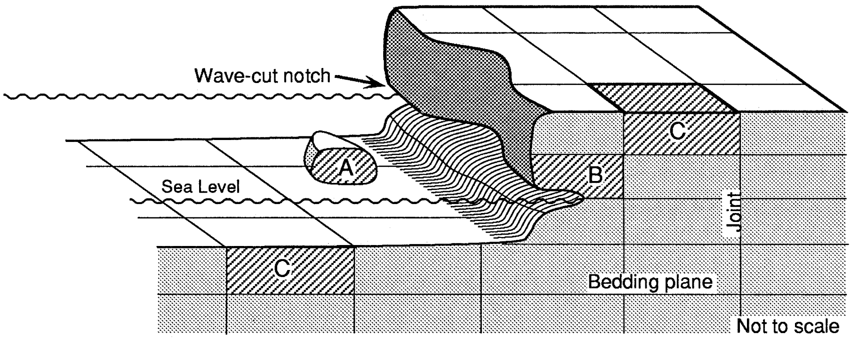

Figure 9. Hypothetical cross-section through old coastline at Blowholes showing locations from which boulders would have been derived. (A) boulders with sponge and bivalve borings and encrusting corals; (B) boulders with flat base and part of wave-cut notch; and (C) boulders with flat base (bedding plane) and flat sides (joints).

type section of the Bluff Formation in the nearby quarry shows that they belong to the upper part of that member. The stratigraphic position of these strata relative to those at Blowholes is not known.

Most of the coastal terrace at Great Pedro Point is the same as zone A at Blowholes, characterized by rugged phytokarst with pinnacles and ridges that have a relief up to 2 m (Figure 8A). The best developed ridges and pinnacles occur alongside joints that cut through the rocks of this area. Like Blowholes, this coastal terrace also has flat, exposed bedding planes devoid of phytokarst (Figures 8A and B). These flat areas, which are bounded by joints, are commonly 1 to 1.5 m below the level of the surrounding terrace (Figure 8B). This difference in relief is not due to downfaulting of the blocks. Inspection of the margins of the blocks shows that cavity-filling deposits cut by joints show no evidence of vertical displacement.

Distribution, Size, Shape, Composition, and Orientation of Boulders

There are more boulders at Great Pedro Point than at Blowholes. Despite this, the boulders have an irregular distribution with clusters of boulders being separated by areas devoid of boulders (Figure 3). The boulders, apart from isolated examples, are located on the landward side of the break in slope (Figures 3 and 4B).

The boulders, formed of microcrystalline dolostone, were derived from the Cayman Member. Most boulders have a oblong, box-like shape with a smooth base, smooth sides, and a rugged phytokarsted upper surface. Some boulders have upward-curved bases at one end (like those at Blowholes) that formed as the upper part of a wave-cut notch. Such blocks always have the upward-curved base at their eastern end like those at Blowholes.

Age of Boulders

The age of the boulders in this area could not be determined because none of them had encrusting organisms that could be used for radiocarbon dating.

SOURCE OF BOULDERS

The lithology of the boulders at Blowholes and Great Pedro Point shows that they were derived from the Cayman Member that forms the coastal terraces. Further clues regarding the original positions of the boulders can be deduced from features evident in the boulders and coastal terrace. For this purpose, the boulders are divided into those with (1) part of a wave-cut notch on their base, (2) borings and *Astrangia*, and (3) no distinctive features other than their flat bases and sides. The latter group are the most common.

Boulders with Wave-Cut Notch

The wave-cut notch evident on some boulders (Figure 5A) at Blowholes and Great Pedro Point shows that they originated from strata that were once at sea level (Figure 9). The wave-cut notch would have developed during a period of sea-level standstill. The notch on boulder #22 at Blowholes has an indentation of about 1.6 m (Figure 6A). On Grand Cayman and Cayman Brac the wave-cut notch produced during the Sangamon highstand approximately 125,000 years ago commonly has indentations of 1.5 to 3.0 m. Thus, it seems probable that the wave-cut notches evident in the boulders at Blowholes and Great Pedro Point are probably of this vintage.

Boulders with Borings and Encrusting Fauna

The presence of sponge and *Lithophaga* borings in some boulders at Blowholes shows that they must have once been submerged in seawater. This suggestion is also supported by the fact that one boulder at Blowholes is covered with *Astrangia,* a coral which generally lives in sheltered niches. The fact that the borings and corals occur on all sides and the top of the boulders suggests that they originated as loose boulders that probably fell from sea cliffs into shallow, nearshore waters (Figure 9).

Boulders with Flat Bases and Sides

Most boulders have no distinctive features other than their flat base (bedding plane) and flat sides (joint surfaces). Clusters of these boulders occur inland from regions on the coastal terrace that are characterized by flat areas which are up to 1.5 m lower than the surrounding phytokarst. This relationship is especially well developed in the Great Pedro Point area (Figure 4). Conversely, areas devoid of boulders occur inland of regions on the coastal terrace that lack the low-lying, flat areas (Figure 4). These observations suggest that the boulders were derived from the flat, low-lying areas on the coastal terrace.

The morphology of the boulders supports the idea that they were derived from the coastal terrace. The flat bases of the boulders are probably bedding planes that correspond to the bedding planes that form the bottom of the low-lying areas on the coastal terrace. The size of the boulders was dictated by bed thickness and the spacing of joints in the Cayman Member. Most boulders at Blowholes are less than 1.5 m high, a dimension that corresponds to the difference in relief between the flat, low-lying and phytokarst areas on the coastal terrace.

Synopsis

Evidence suggests that boulders at Blowholes originated from a relatively mature coastline that was characterized by a sea cliff with a wave-cut notch, boulders in the nearshore waters that were derived from the sea cliff, and a sea floor and coastal terrace that were formed of bedded, jointed dolostone (Figure 9).

DISCUSSION

The Blowholes and Great Pedro Point areas differ from other areas along the south coast of Grand Cayman because they are characterized by high energy conditions and have exposed coastal terraces formed of dolostones that belong to the Cayman Member. Both areas receive the full impact of the onshore waves, a fact that is especially pertinent during severe sea conditions. Other stretches along the south coast are characterized by sandy beaches or mangrove swamps because the power of the onshore waves is reduced by offshore reefs.

The boulders at Blowholes were moved onshore approximately 330 years ago. Although the coastal area probably had a profile similar to the present-day situation the morphology of the boulders suggests that there was also a small sea-cliff with a wave-cut notch along the break in slope that denotes the position of the Pleistocene shoreline (Figure 9). The boulders with the borings and the marine encrusters originated in the coastal waters that are up to 10 m deep even in areas close to shore. Thus, boulder #51, which is 2.0 m × 2.0 m × 1.3 m in size (estimated weight of 10 tonnes), must have been moved 15 to 18 m vertically and at least 50 to 60 m horizontally. Other boulders that originated in zone A on the coastal terrace were moved up to 5 m vertically and 50 to 75 m horizontally. The boulders with the wave-cut notches did not move so far because most of them are close to the Pleistocene shoreline.

At Great Pedro Point, none of the boulders originated on the seafloor. At the present day, the vertical sea-cliffs at Great Pedro Point descend beneath sea level, without a break in slope, to a depth of 10 to 15 m. The seafloor in front of these sea-cliffs is characterized by large boulders that have been derived by the undercutting and collapse of the present sea cliffs. These are probably the modern day equivalents of the bored and encrusted boulders that occur at Blowholes. At Great Pedro Point, however, such boulders would have to be lifted 45 to 50 m vertically. This appears to have been beyond the capabilities of the hurricane. Most boulders in this area originated from zone A of the coastal terrace. As such, most have moved 5 to 6 m vertically and 100 to 150 m horizontally.

An unusual feature of the boulders at Blowholes and Great Pedro Point is their irregular, patchy distribution along the shoreline (Figures 2 and 3).

Such a distribution suggests that other factors may have influenced the movement of these boulders by locally accentuating the effects of the onshore waves. The occurrence of the boulders inland from the exposed bedding planes on the coastal terrace shows that they are giant 'rip-up' clasts torn away from the bedrock. The boulders and exposed bedding-planes occur inland of indentations in the modern coastline (Figure 3). This is most evident in the Great Pedro Point area where major indentations have preferentially developed along solution-widened joints that are now filled with lithified terra rossa. Observation of the modern coastline in this area shows that incoming waves are funnelled into the indentations with the result that water level rises towards the head of the indentation. As a result, the waves breaking at the heads of the indentations are larger and expend more energy than those on the sides of the indentation. This mechanism creates differential energy levels along a short stretch of coastline; a fact that would be even further magnified during severe sea conditions. The water was then funnelled along bedding planes in such a way that it was able to lift and move blocks off the bedding planes. Once loosened from the bedrock, the waves then carried the boulders further onshore.

The boulders on Grand Cayman are remarkably similar to storm boulders that occur on Mitiaro and Mauke in the southern Cook Islands. On Mitiaro, one storm boulder, 2.2 m high, occurs 200 m from the present shoreline at an elevation of 4.85 m (STODDART *et al.*, 1990). Other smaller boulders occur 9 to 47 m from the shoreline at elevations of 5.11 to 6.75 m (STODDART *et al.*, 1990). The presence of corals in some boulders led STODDART *et al.* (1990) to suggest that they were derived from the reef. Although the age of these boulders is not known, STODDART *et al.* (1990) suggested that a hurricane, similar to the one in 1865 which generated waves up to 9 m high, may have moved the boulders onshore. Storm boulders, up to 2.0 × 1.5 m, also occur at considerable distances from the shoreline on Aitutaki (STODDART, 1975: Plate 17).

Estimating the power of the waves responsible for the movement of the boulders at Blowholes and Great Pedro Point is difficult because there does not appear to have been another one of comparable power in recent history. Such waves may have been generated during a severe hurricane or by a tsunami triggered by a major earthquake or slumping on the nearby submarine slopes.

Although early historical records are scanty, there is mention of a hurricane in 1785 that generated a tidal wave which destroyed every house on Grand Cayman and uprooted every tree except for one (WILLIAMS, 1970). The low-lying land on Grand Cayman was submerged during the 1846 hurricane with the seas crossing the entire width of the island near Newlands (just north of Great Pedro Point). The 1910 hurricane produced waves up to 5 m high whereas an eyewitness account of the 1932 hurricane estimated winds at 200 mph (329 km/hr) and described a sea that '... swept high over the coast, carrying huge rocks on its crest and the wind hurled rocks, some weighing tons, through the air' (WILLIAMS, 1970, p. 73). The 1932 hurricane was largely responsible for the construction of boulder ramparts formed of coral heads, 0.6 to 1.0 m in diameter, that originated in water less than 15 m deep (RIGBY and ROBERTS, 1976). Nevertheless, these hurricanes do not appear to have generated the power of the waves that moved the boulders onshore in 1662. STODDART (1980) reported the occurrence of storm boulders (1.2 × 1.5 × 1.5 and 1.8 × 1.5 × 1.5 m) on Little Cayman but did not provide any information as to their age or composition. It seems entirely possible that a hurricane in 1662 may have been responsible for the transportation of the boulders. Although the first settlers arrived on Grand Cayman about 1658, there appears to be little written record of conditions in those early years.

Tsunami can quickly devastate low-lying coastal areas. In 1692, Port Royal on the south coast of Jamaica was swamped by a large tsunami, triggered by a major earthquake, in a matter of 3 minutes (LINK, 1960). Records from that time indicate that the wave picked up a large ship (8 to 12 tons) and moved it inland over houses that were 2 to 4 stories high (LINK, 1960). Deposition of Pleistocene conglomeratic deposits formed of coral and basalt boulders, 326 m above sea level on the coast of Lanai, was also attributed to a tsunami that was caused by submarine slumping (MOORE and MOORE, 1984).

Determining the origin of the giant waves that eroded the coastal terrace and moved large boulders onshore on the south coast of Grand Cayman is difficult because of the lack of other evidence. Movement by hurricane induced waves is equally as feasible as by a tsunami. The proximity of Grand Cayman to the Cayman Trench with its active spreading centre and faults means that tsunami could easily have been generated by earthquake activity. Irrespective of the cause, it is evident that no waves of comparable power have affected Grand Cayman since 1662.

The recognition that erosional levels on rocky coastal terraces may be eroded by giant waves carries important implications for studies that use such features for estimating past sea-levels. For example, EMERY (1981) suggested that the +2 m, +4 m, +6 m, +8 m, +11 m, and +15 m terraces on the south coast of Grand Cayman probably recorded past sea levels. Similarly, WOODROFFE *et al.* (1983) used some of these terraces in their examination of fluctuating sea levels on Grand Cayman. JONES and HUNTER (1990) have already demonstrated the danger of using these terraces to pinpoint the highstand during the Sangamon. The present study has demonstrated that terraces along rocky shorelines can be substantially modified by onshore wave activity. The plucking of large boulders from the terrace can expose large flat areas along bedding planes that look similar to erosional terraces formed during sea level highstands.

CONCLUSIONS

Analysis of boulders at two localities on the south coast of Grand Cayman shows that this island was subjected to immensely powerful wave action in approximately 1662 AD. This was either a hurricane induced wave or a tsunami triggered by earthquake activity or submarine slumping. Indeed, it appears that no other waves of this magnitude have passed over the island since that time. The giant wave of 1662 was so powerful that it was able to pick up 10 tonne blocks from the seafloor and move them 15 to 18 m vertically and 50 to 60 m horizontally. Removal of large boulders from the rocky coastal terrace substantially modifies their morphology and elevation. This carries important implications for studies that use such features for estimating the height of past sea levels highstands.

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□ RÉSUMÉ □

Sur la côte rocheuse du Grand Cayman, il y a des blocs qui atteignent 5.5 m de long, 2.3 m de large et dont le poids est estimé à au moins 40 tonnes. Les groupements de blocs, qui sont distribués de manière irrégulière sur la surface, se situent jusqu'à 100 m à l'intérieur des terres du littoral actuel. Tous ces blocs proviennent de roches dolomitiques microcristallines de la formation de Bluff qui constitue les terrasses de cette zone. La présence de tous de *Lithophagia* et les *Homotrema* présents sur certains blocs, montrent que certains d'entre eux ont dû être submergés avant leur transport dans la position actuelle. Un des blocs est couvert d'*Astrangia solitaria.* La datation de ce corail donne un âge de 1662 (1625 à 1688, intervalle de confiance: 68.3%), âge qui reflète probablement l'époque où le corail a été soustrait à l'environnement marin.

L'analyse de blocs suggère qu'ils ont été transportés dans leur position actuelle par une ou plusieurs ondes géantes qui ont balayé le Grand Cayman, il y a environ 330 ans. De telles ondes déplacèrent des blocs pesant près de 10 tonnes, jusqu'à 18 m en hauteur et à 50 ou 60 m en plan. Ces blocs peuvent avoir été déplacés par une onde générée par un hurricane ou un tsunami provoqué par un tremblement de terre ou un effondrement sur les pentes sous marines. Aucune onde comparable n'a affecté l'île depuis 1662.—*Catherine Bousquet-Bressolier, Géomorphologie E.P.H.E., Montrouge, France.*

□ RESUMEN □

Dos segmentos de costas de las islas del Gran Cayman están caracterizados por rocas de hasta 5.5 m de largo, 3.4 m de ancho, y 2.3 m de alto (con un peso estimado del orden de las 40 toneladas). Estos agrupamientos rocosos, se hallan irregularmente distribuídos a través del área, y desplazados hasta unos 100 m hacia el interior del continente desde la actual línea de la costa. Todas la rocas derivaron de los agrupamientos rocosos microcristalinos de la Formación Bluff que forman las terrazas costeras de estas áreas. La presencia de orificios de esponjas, *Lithophaga,* con incrustaciones de gasterópodos e incrustaciones de *Homotrema* en algunas rocas, demuestran que deben haber estado sumergidas en agua de mar, previo a su desplazamiento a la posición actual. Una roca se hallaba también cubierta con *Astrangia solitaria.* La datación de este coral por medio del radiocarbono dió ccomo originada en 1662 (con un intervalo de confianza de 68.3%); edad que probablemente refleja el tiempo en el cual coral fue removido del ambiente marino.

Los análisis de las rocas sugieren que ellas fueron transportadas a su actual posición por una ola gigante que cruzó barriendo el canal del Gran Cayman hace aproximadamente unos 330 años. Estas olas han movido algunos bloques de 10 toneladas, verticalmente hasta 18 m y horizontalmente 50 a 60 m. Estas rocas pueden haber sido movidas por olas generadas por huracanes o tsunamis originadas a su vez por un terremoto o deslizamientos sobre las pendientes submarinas. Desde 1662 no han habido olas de potencia comparable que hayan afectado a las islas.—*Néstor W. Lanfredi, CIC-UNLP, La Plata, Argentina.*

□ ZUSAMMENFASSUNG □

Zum charakteristischen Inventar zweier Felsküstenabschnitte auf der Insel Grand Cayman gehören Felsblöcke, die bis zu 5.5 m lang, 3.4 m breit und 2.3 m hoch sind und ein geschätztes Gewicht von bis zu 40 Tonnen aufweisen. Blöcke, die unregelmäßig über das Küstengebiet verteilt sind, treten bis zu 100 m landeinwärts in Gruppen auf. Alle Blöcke stammen aus dem mikrokristallinen Dolomit der Bluff-Formation, welche die Strandterrassen des Küstengebietes aufbaut. Das Auftreten von Bohrspuren durch Schwämme und *Lithophaga* sowie Spuren von sich inkrustierenden Gastropoden und *Homotrema* auf einigen Blöcken zeigen an, daß zumindest einige von ihnen vor ihrer Ablagerung am heutigen Lagepunkt vom Meer bedeckt waren. Ein Block ist außerdem mit *Astrangia solitaria* bedeckt. Die C-14-Datierung dieser Koralle erbrachte ein Alter von 1662 Jahren n.Chr. (+26/−37 Jahre, 68.3% Sicherheitswahrscheinlichkeit). Dieses Alter gibt wahrscheinlich den Zeitpunkt an, zu dem Block und Koralle dem marinen Milieu entzogen wurden.

Die Untersuchung der Blöcke legt den Schluß nahe, daß die Blöcke durch mindestens eine Riesenwelle, die sich vor ca. 330 Jahren über die Grand Cayman-Insel ergoß, in ihre jetzige Position gebracht wurden. Diese Wellen brachten 10 Tonnen schwere Blöcke auf eine Höhe von bis zu 18 m ü.M. und transtportierten sie maximal 50–60 m landeinwärts. Wahrscheinlich wurden diese Blöcke durch Wellen verlagert, die durch entweder durch einen Hurrikan verursacht worden waren oder aber durch Tsunamiwellen, die als Folge eines Erdbebens oder einer submarinen Rutschung auftraten. In den Zeit zwischen 1662 und heute gibt es keine Berichte über Wellen vergleichbarer Größenordnung.—*Ulrich Radtke, Geographisches Institut, Universität Düsseldorf, Germany.*