Chapter 8
The Cockpit Country of Jamaica: An Island Within an Island

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Abstract Cockpit karst landscapes are among the most distinctive and unique landscapes in the world, and have attracted attention from scientists and tourists alike from across the world and throughout recorded history. So named because of the bowl-shaped depressions resembling cock fighting arenas, its “type area” is the Cockpit Country in Jamaica, a rugged area dubbed “terra incognita” by early colonial settlers. A dramatic example of tropical karst topography, of which there are several, the Cockpit Country displays the best-developed type of cockpit karst in the world, a function of the material properties of the underlying limestone, water table depth, and tectonic setting as much as the climate in which it was formed.

Keywords Cockpit country • Cockpit karst • Jamaica • tropical karst evolution

8.1 Introduction

Cockpit karst landscapes are among the most distinctive landscapes in the world, and have been the focus of much scientific study over the past half century. A dramatic example of tropical karst topography, the terrain and its constituent landforms are the products of the unique properties of the limestones in which they form, climatic influences, and the tectonic setting of the karst region. The cockpit type of karst landscapes has its best expression in Jamaica, where the type area for this landscape – the Cockpit Country – is found.

Cockpit karst refers to an assemblage of enclosed cockpit depressions and residual hills (Sweeting 1972). Cockpits themselves are deep, irregularly shaped depressions in the landscape through which water is conducted underground; residual hills surround these depressions. However, there has been some disagreement over the past century as to the nature of cockpit karst. This is reflected in the confusing terminologies derived for areas with similar landforms, with names ranging from Kegelkarst to cone karst, all purportedly describing similar landscapes. Recent studies have added further quantitative descriptions of cockpit karst landscapes, showing that cockpit karst areas have pronounced vertical relief development over a relatively short horizontal space, with significant topographic roughness (Lyew-Ayee et al. 2007), distinguishing these areas from other landscapes, karst or otherwise.

Cockpit karst areas are typically found in areas with high rainfall. Sweeting (1972) mentioned that both high amounts and high intensities of rainfall are required for the development of cockpit karst, because high rates of solution would be required to sculpt the landscape. But high levels of rainfall alone would not result in the development of a cockpit karst landscape. It would require the limestone to be hard and compact, with marked development of fracture systems through which water would be vertically redirected to begin and continue sculpting the terrain. It is the combination of these factors that would result in the development of a cockpit karst landscape.

It is the geology of the limestone – its lithology and structure – that plays an important role as a control on cockpit karst development. Monroe (1966) commented, from his observations in Puerto Rico, that different lithologic units gave rise to different types of karst phenomena, while Day (1978), in his study of tropical karst landscapes across the Caribbean, looked at the material properties of the limestone – hardness, purity, petrology, and porosity – as well as the structural patterns of joints and faults. One of his key findings was that high limestone purity and high mechanical strength were the main controls...
on cockpit karst development, a fact confirmed by more recent research (Lyew-Ayee 2004). In addition to these lithological controls, structure also plays a very important role. Fractures, joints, bedding planes, and faults all serve to redirect and control the movement of water through the karst terrain, resulting in preferential solution occurring. As a result, certain areas in the limestone landscape are dissolved at a faster rate than others.

Another important control is the karst base level, where water draining vertically through the limestone meets an impermeable stratum or the water table, at which point the water begins to flow laterally underground. Where the base level is at great depth, the dissolution of the limestone can continue vertically, and surface landforms have pronounced vertical development. These factors – geological and hydro-meteorological – operating in tandem, result in the development of cockpit karst landscapes.

8.2 Geographic Setting

Cockpit karst landscapes are not limited to Jamaica. Other areas in the Caribbean have them too – those in Belize and Puerto Rico have been well-documented (Day 1978, 1982; Monroe 1966) – and other areas around the world have been described as having similar landscapes with alternating hills and depressions. While other places in Jamaica also have cockpit karst topography, the region known as the Cockpit Country has the most dramatic and extensive cockpit karst development on the island.

Jamaica is the third largest island in the Greater Antilles, in the western part of the Caribbean Sea, located roughly 18°N and 77°W. The island lies on the eastern end of the Nicaragua Rise, a topographic extension of northern Central America, and is separated from Cuba to the north by the 7,200 m deep Cayman Trough.

The island is essentially divided into two broad physiographic units: the Eastern Mountain Mass, with Cretaceous and Eocene elastic rocks, and the Main Block, which consists of dissected limestone plateaux, in which karst features have their best expression. Tectonic displacement in the early Cenozoic had the effect of “breaking up hard limestone beds and increasing its permeability” (Versey 1972: 450). He also added that this block was uplifted in the Miocene in a manner similar to that of a large calcareous shoal, with no drainage superimposed upon it. The future karst landscape would depend on the character of the newly exposed limestone, as well as the amount of uplift (which influences the karst base level) and fracturing. The tectonic activity also resulted in the exposure of Cretaceous-age volcanoclastic rocks beneath the limestone, which led to allogenic runoff on to the surface of the adjacent limestone beds, contributing to both chemical and mechanical erosion from the sediment-laden waters.

It is in this environment and system that the Cockpit Country developed. Situated on the Main Block, it makes up part of a limestone plateau, reaching altitudes of more than 900 m a.s.l., developing on the hard and pure White Limestone Group found in this area. Other spectacular karst features are found along this plateau, for example, the degraded karst of the Dry Harbour Mountains (Sweeting 1958; Day 1978) and the interior valley (polje) at Lluidas Vale (Landmann 1990), although none as spectacular as the Cockpit Country. First described in 1869 by Sawkins, for whom the ruggedness of the terrain was “well deserving of the appellation terra incognita,” the Cockpit Country remains to this day an area of undisturbed natural beauty of immense interest to scientific study (Figs. 8.1–8.3).

The Cockpit Country is defined to the north and east by major fault systems, with a significant lithological change in the limestones to the east as well. The southeastern and western boundaries are defined by outcrops of volcanoclastic material, which also result in a very different topographic character in these places. These areas also have surface drainage which contributes allogenic material into the karst hydrosystem of the Cockpit Country. The southern boundary is defined by interior valleys, with extensive areas of gentle relief development (Fig. 8.4).

The region has strong historical significance, with many pre-Columbian Taino Indian artifacts found in the caves within the Cockpit Country, as well as Maroon settlements with the descendants of runaway slaves from the sugarcane plantations that surround the region, who used the rugged terrain to escape and evade colonial soldiers.
8.3 Landforms

It is the assemblage of the different landforms that comprise the overall landscape. While cockpit karst landscapes are invariably described as having alternating residual hills and enclosed depressions, these often have very different forms.

Cockpit depressions average more than 50 m in depth, and are distinct from dolines, "the diagnostic karst feature" (Ford and Williams 2007), in both the depths of the cockpits as well as in planar complexity (dolines tend to have simpler planar forms). Cockpits often occur with multiple sinks per depression through which surface water is redirected downward. While some researchers (Sweeting 1972; Miller 1998; Mitchell et al. 2003) have described cockpit depressions as being star-shaped in plan, this is a very qualitative generalization. Depressions have various shapes and forms, ranging from simple circular cockpits (different from dolines and other karst depressions because of their depths) to very irregular depressions. Elongated glades form when depressions develop along a fault or major joint set, which controls the orientation of the landforms, while uvalas are formed when cockpits coalesce. While cockpits have been described as having steep slopes (Sweeting 1958, 1972), a depression may have very steep slopes along parts of its sides, with gentler slopes on other sides; in both plan and profile, depressions are highly irregular.

Cockpit depressions are formed at the intersection of major joint sets, where dissolution of limestone by water traveling along these is greatest. It is along such lines of secondary porosity that much of the surface water is redirected into the rock, resulting in preferential dissolution of the limestone in these areas. The limestones found in the Cockpit Country already have fairly low primary porosities due to recrystallization and case-hardening. Where the limestone stratum is thick, and the karst base level at great depth, the vertical flow of water (and its solutinal effects) along the fractures continues to sculpt the landscape and maintain the characteristic relief of the cockpits.

The surrounding residual hills are (broadly) relicts of the original limestone plateau. They generally have
concordant summits, with vertical dissolution of the limestone largely concentrated in the depressions. Hills are generally more interconnected than the isolated cockpits, with “saddles” connecting individual hills and separating cockpits. The hills may have undercut notches at their bases, where lateral dissolution may occur from the ponding of water in depressions following heavy rainfall. Caves may also be associated with the sides of hills, these being remnants of former underground water channels that have been uplifted and subsequently exposed. It is in these caves that there have been archaeological discoveries associated with Taino settlements.

Both depressions and residual hills show a narrow horizontal spacing; these features are generally close to each other, with sinks and summits roughly 100 m apart from each other on average. The resulting density of features, coupled with the high range in elevation (between 50 m and 100 m) between these features, give the Cockpit Country its characteristic rugged landscape.

8.4 Landscape

Ultimately, as the type area for cockpit karst, all descriptions of the cockpit karst of Jamaica refer to the Cockpit Country. The region is not homogeneous; cockpit karst dominates the Cockpit Country, but does not compose the entire region: elongated glades (described later) and localized areas of lateral corrosion result in some areas not attaining the same vertical development of the landscape as other places. On the
whole, however, the landscape shows very pronounced vertical relief development, especially when compared to the landscapes which surround the Cockpit Country, as well as a greater degree of topographic roughness (Lyew-Ayee et al. 2007). These surrounding regions show a mix of tower karst topography (in areas where the karst base level is near the surface, which promotes lateral dissolution of the landscape) and doline karst (in areas of more impure limestone), as well as entirely non-limestone regions devoid of karst. In all these landscapes, however, the level of vertical terrain development, as well as the narrow horizontal spacing of features, attained in the Cockpit Country is not present.

Other karst landscapes surround the Cockpit Country. There are interior valleys (poljes) to the north and south of the region, with portions of tower karst contained therein, as well as pockets of doline karst areas. To the east lies an area of degraded karst, described by Sweeting (1958) and Day (1982) as a modification of existing cockpit karst, where deepening of cockpits has ceased, resulting in the sides of the depressions slumping in, reducing slope angles. The cockpits, as a result, become less deep (from the slumping of the sides as well as accumulation of talus deposits and bauxite deposits in these depressions) and morphologically distinct from the cockpit karst in the Cockpit Country. Here, there are large elongated glades where cockpits coalesce and develop parallel to the existing fracture orientations. The limestone in this region is lithologically different from that found in the Cockpit Country, but the area is found on the same limestone plateau as the Cockpit Country, with similar karst base level depths and local climate, and, as such, illustrates nicely the lithological controls on cockpit karst development.

Ultimately, the cockpit karst of the Cockpit Country is distinct from other similarly described landscapes with alternating series of karst depressions and residual hills. Cockpit karst is not cone karst; the former describes negative relief landforms in the landscape, while the latter describes positive relief features.
Fig. 8.4 Cockpit Country location map

Cone karst areas were described in the Far East by Lehmann (1936), and Jennings (1972) noted the full, rounded shapes of the hills, while Sawkins commented in 1869 on the cockpit depressions in Jamaica resembling arenas used for cockfighting. The cone karst of Gunung Sewu (whose name means “thousand hills” in Javanese) in Java, Indonesia, was described in 1845 by Junghuhn, who noted the extensive series of hills there. These (qualitative) perceptions of scientists and observers over the past century and a half seem to describe two very different landscapes. There is no such thing as cockpit cone karst.

8.5 Morphogenesis

Hill’s (1899) model of karst landform development in Jamaica (Fig. 8.5) was largely simplistic, but correctly considered both rock type and the karst base level as important controls in landscape evolution, and is still relevant more than a century later. This model predated hypotheses on karst landscape evolution by Grund in 1914 and Cvijić in 1918, yet all maintained that an initial limestone surface was sufficiently weathered, producing karst landforms, and, over time, an impermeable rock stratum is exposed which does not support further karst development.

The limestone plateau upon which the Cockpit Country developed would have had no drainage superimposed on it. This corresponds to Hill’s Stage I of karst development. The exposed limestone was then subjected to surface weathering, and karstification began. Local conditions, however, would determine the extent of karstification and the variety of landforms produced. The Cockpit Country would represent Stage II of Hill’s model.

However, the simple linear progression of karst development, from uplifted shoal to cockpit karst
Fig. 8.5 Hill’s evolutionary model for karst morphogenesis in Jamaica

landscape, to the complete removal of limestone cover and destruction of the karst environment, may be incorrect. The generalized models by Hill (1899) and Smith et al. (1972), both of which were based on research done in Jamaica, did not consider the effect of the allogenic contribution of low-permeability material which would form a superficial karst base level and accelerate the destruction of the karst surface.
Fig. 8.6 Revised evolutionary model for karst morphogenesis in Jamaica. Stage B is a DEM of an actual part of the Cockpit Country. Evolution is controlled by the lithology of the White Limestone, the height above the karst base level at the Yellow Limestone contact, and the fractures in the landscape which influence the vertical transmission of water surface weathering since. However, the fact that not all features contained in the region are uniform, even in areas with similar lithology, suggests that different processes are at work. While solution is the main process at work in sculpting the Cockpit Country, local hydrological and geological conditions dictate the effectiveness of this. The alignments of fractures, as well as the effect of allochthonous drainage, all served to influence how the region developed. As a result, while still composed of alternating cockpits and residual hills, these landforms do not necessarily have uniform characteristics.

8.6 Conclusions

The unique landscape of the Cockpit Country is certainly one of the most interesting places in the Caribbean. The rugged landscape there also supports one of the highest densities of endemic species of flora and fauna in Jamaica, resulting in a great deal of ecological...
interest in the region in recent times. Certainly, over the past few years, the bulk of Cockpit Country research has focused on this aspect of the region. Studies have also focused on the historical aspect of the Cockpit Country region (Lyew-Ayee and Conolley 2008), with the recent discoveries of significant Taino artifacts in the area.

However, it is the geomorphology of the place that resulted in the Cockpit Country supporting such species endemism, with the ruggedness of the terrain deterring human encroachments; its cave systems attracted Taino ceremonial burials. This combination of scenic value, historical interest, and biodiversity has resulted in the Cockpit Country becoming worthy of local, regional, and international interest, scientifically, culturally, and otherwise. After all, it is one of the most exciting karst landscapes on Earth.

The Author

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References