JAMAICAN CAVES AND CAVE EXPLORATION

JAME NA JAMAJKI IN NJIHOVO RAZISKOVANJE

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Fincham, Alan G.: Jame na Jamajki in njihovo raziskovanje

Jamajka, otok v Velikih Antilih, meri več kot 11.000 km^2, dve tretjini sta zgrajeni iz zakraselega apnenca z največjo višino okoli 1.000 m n.m. Podatkov o raziskavah v 18. in 19. stoletju je malo, raziskovanje jam na otoku se razmahne po 1940, ko so začeli izkoriščati guano kot gnojilo. V zadnjem času pa se je spoznavanje jam in krasa na Jamajki poglobilo zaradi številnih "ekspedicij" iz Severne Amerike in Evrope. Jamarski klub Jamajka, osnovan 1958, je glavno središče za obiske tako jamarjev kot speleologov. Jamski kataster obsega več kot 1200 jam in verjetno so do sedaj raziskane večinoma vse večje in lažje dostopne jame. Največja do sedaj dosežena dolžina jame je 3.500 m oziroma globina 180 m. Speleološke raziskave na Jamajki so prispevale k svetovni geomorfološki, hidrološki, paleontološki, arheološki in biospeleološki literaturi. Čeprav je Jamajka gospodarsko odvisna od turizma, je do sedaj zelo malo urejenih turističnih jam. Porast prebivalstva in gospodarski pritiski na otoku bodo verjetno povečali ogroženost jam, zato priporočamo razvoj strategije za varstvo v sodelovanju zasebnih in državnih teles.

Ključne besede: regionalna speleologija, novejše raziskave, literatura, varstvo jam in krasa

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Fincham, Alan G.: Jamaican Caves and Cave Exploration

The island of Jamaica in the Greater Antilles, has a land area in excess of 11,000km^2, two-thirds of which consists of cavernous limestones with a maximum elevation of about 1,000m a.s.l.. Records of explorations from the 18th and 19th centuries are few, but cave exploration in the island became more active in the 1940's when bat guano deposits were exploited as fertilizer. More recently, knowledge of Jamaican caves and karst has been enhanced by the activities of a series of "expedition" parties from both North America and Europe. The Jamaica Caving Club, formed in 1958, has acted as a focus for the work of both visiting cavers and speleologists. The present cave data-base contains records of over 1,200 sites and it is probable that most of the larger, more accessible caves have now been explored. The greatest mapped extent and depth for Jamaican caves are 3,500m and 180m, respectively. Jamaican speleological research has contributed to world geomorphological, hydrological, palaeontological, archaeological and bio-speleological literature. Although Jamaica is economically dependent on tourism, the organized development of "show-cave" sites has been minor. Existing population and economic pressures within the island are likely to increase cave-site endangerment, and the development of conservation strategies by the coordination of both private and government bodies is suggested.

Key words: regional speleology, recent explorations, literature, caves and karst protection

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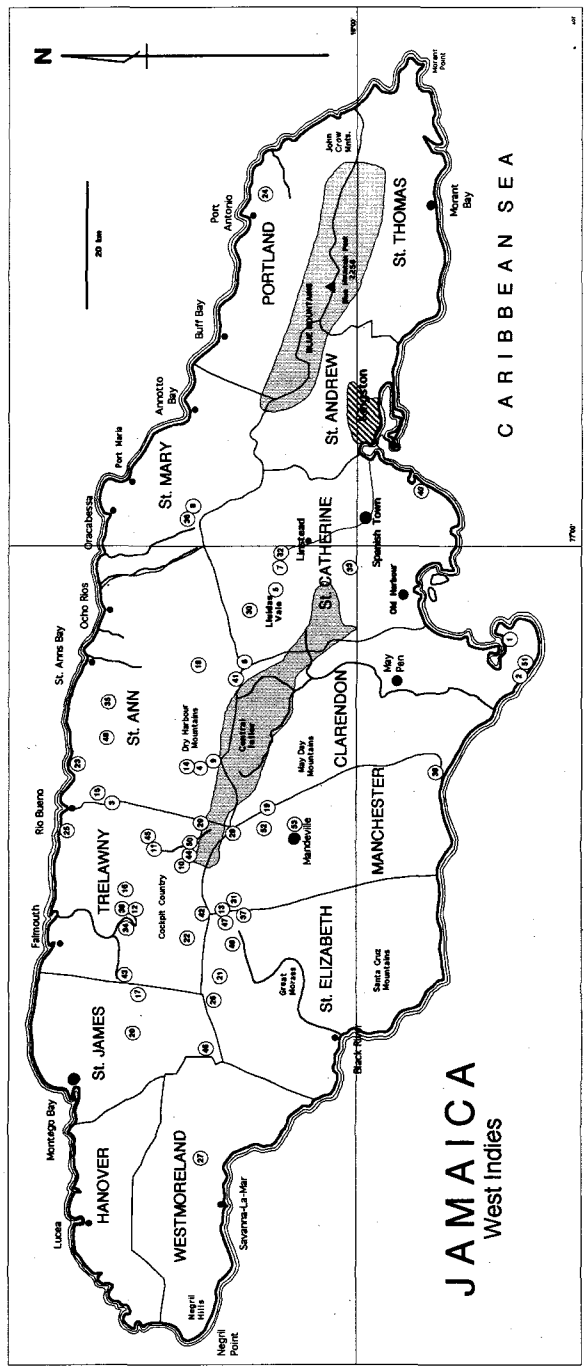
BACKGROUND

The associated article (Shaw T.R.,), provides an account of the karst literature of Jamaica covering the period from the Spanish invasion of the island (1509) to the outbreak of World War II in 1939. In this chapter, the author seeks to bring the reader an account of the more recent Jamaican karst literature and to provide an outline of the present status of Jamaican speleology.

THE TERRAIN

The island of Jamaica (Figure 1) has a land area of about 11,420km^2 of which almost exactly two-thirds of the surface rocks of are faulted limestones of Eocene to Miocene age (Robinson et al., 1977; Horsfield, 1974). Generally, the land is mountainous and much of the inland terrain is characterized by rugged areas of "Cockpit" and "Tower" karst with a local relief of over 100m, interspersed with poljes ("Glades" or "Bottoms"), making these regions difficult of access and of poor agricultural potential, apart from forestry and some subsistence farming within the glades.

The main exposure of non-carbonaceous rocks occurs in the Blue Mountain Range; a ridge of peaks of about 2,300m which comprises much of the eastern interior of the island. The principal cave-bearing formation is that of the White Limestone of Middle Eocene to Middle Miocene age within which many of the major caves of the interior are developed (Wadge & Draper, 1977c). Younger limestones comprise the coastal formations of the island (e.g. Portland Ridge and the Hellshire Hills) and also contain notable caves. Some limestones (e.g. The Newport Formation of the White Limestone) are over 1500m in thickness, but caves of a depth greater than about 250m have not been found (Wadge & Draper, 1977a). The hydrology of the island is dominated by a series of rivers which generally sink around the northern edges of the Central Inlier (Figure 1) feeding to risings associated with the E-W Duanvale fault system which is a dominant feature of the morphology of the central-northern Cockpit Country and the Dry Harbour Mountain region of the island. In many cases the underground drainage distribution has been determined through water-tracing studies and some sink-to-rising distances in excess of 20km have been established (Smart & Smith, 1976).


N
20 km
JAMAICA
West Indies
CARIBBEAN SEA
HANOVER
WESTMORELAND
ST. JAMES
TRELAWNY
ST. ANN
ST. MARY
PORTLAND
ST. THOMAS
ST. ANDREW
ST. CATHERINE
CLARENDON
MANCHESTER
ST. ELIZABETH
Montego Bay
Lucea
Negril Point
Savanna-La-Mar
Falmouth
Rio Bueno
St. Ann's Bay
Ocho Rios
Oracabessa
Port Maria
Annotto Bay
Buff Bay
Port Antonio
Kingston
Spanish Town
Old Harbour
May Pen
Mandeville
Black River
Morant Bay
Cockpit Country
Dry Harbour Mountains
Central Inlier
May Day Mountains
Great Morass
Santa Cruz Mountains
Blue Mountains
John Crow Mtns.
Negril Hills

CAVE EXPLORATIONS; 1940 - 1990

(a) The Geological Survey Department: Although some early geologists and naturalists working in Jamaica (e.g. Gosse, 1851; Sawkins, 1869; de La Beche, 1827) commented on the occurrence of caves in various parts of the island, no detailed studies were made. The stimulus for a detailed investigation of the island's caves came about through the need for a local supply of fertilizer during the early years of World War II, when the Jamaican Geological Survey Department (GSD) embarked on an island-wide survey of caves for bat-guano as a possible solution to the fertilizer shortage. The initial project under this scheme included the survey of the well-known **Portland Ridge Caves** in south Clarendon where a guano mining operation was undertaken (Edwards, 1942).

In the forefront of this work was the late Mr. Brian R.G. McGrath, a "surveyor" to the GSD (Several other GSD employees also contributed to this work; most notably; B.V. Bailey and H.E. Edwards). In his field-books McGrath left notes on many caves throughout the island, recording the character and quantities of guano, together with topographic plans and sections of some of the larger, more accessible caves. While McGrath was employed to carry out this work, it is clear from his notes that he had a genuine caver's enthusiasm for

Key to Map Locations

1	Portland Ridge Caves.	2	Jackson's Bay Caves
3	Dunn's Hole	4	The Volcano
5	Worthy Park Caves	6	Pedro Cave and Pedro River sink.
7	Riverhead Cave; Black River.	8	Rock Spring Caverns, Dog Hole.
9	Cave River Sink.	10	Mouth River Sink.
11	Quashies River Sink	12	Windsor Great Cave.
13	Coffee River Cave.	14	Asuno Hole.
15	Dornock Head Rising.	16	Fontabelle Spring.
17	Peterkin and Rota Caves.	18	Hutchinson's Hole.
19	Cabbage Hall Caverns.	20	Mafoota River Caves.
21	Still Waters Cave.	22	Marta Tick Cave
23	Runaway Bay Caves.	24	Nonsuch Cave.
25	Braco Cave	26	Wondrous Cave
27	Roaring River Cave.	28	Gourie Cave.
29	Lowes River Sinks	30	Swansea Cave
31	Oxford Cave	32	St.Clair Cave
33	Mountain River Cave	34	Pantrepant Cave
35	Chesterfield Cave	36	Man Cave
37	Wallingford Cave	38	Long Mile Cave
39	God's Well	40	Two Sisters Cave
41	Blue River Sink	42	Hectors River Sinks
43	Deeside Risings	44	Printed Circuit, Mouth Maze
45	Bristol Cave	46	Me No Sen Cave
47	Golding River Cave	48	Thatchfield Great Cave
49	Falling Cave	50	Harties Caves
51	Lloyds Cave	52	Morgans Pond Hole
53	New Hall Cave		

this study and may be thought of as Jamaica's first caver. Despite this enthusiasm, McGrath was not generally equipped for vertical descents and usually terminated his exploration when low passages, deep water or vertical drops were encountered. Thus, in several cases, major cave extensions have since been made beyond points where McGrath's plans show closure. The Annual Reports of the GSD for 1954-57 include an item on; *"Topographic and Cave Surveys"*, and for 1954-55 the report notes that: *"... eleven caves were surveyed, eight in the parish of Clarendon and three in St. Catherine. One of the longest in the former parish is Long Pond Cave, situated east of Jackson's Bay, Portland Ridge. The length is nearly 400ft., with several offshoots on either side; it has an abundance of stalactites and stalagmites, with beautiful curtains. There are, however, no phosphates in this cave."* (Zans, 1957).

If McGrath was the first caver, the then Director of the GSD, Dr. V.A. Zans, may be credited as the first speleologist. Zans appears to have directed much of McGrath's earlier work and contributed some of the first detailed studies of Jamaican caves, for example, in his paper; *"The Geology of the Mosely Hall Cave"*, (Zans, 1953). (See also: Zans, 1951; 1954; 1958; 1959). McGrath also contributed to the literature with his account; *"A Descent into Dunn's Hole Sink"* (McGrath, 1958) being the most noteworthy in that this assault on the 230m deep sinkhole was made using cable ladders and in collaboration with a visiting part of cavers from the US National Speleological Society (NSS), (White and Dunn, 1962).

In addition to the cave surveys, the concerns of the GSD also centered around the hydrology of the island. In 1955, Dr. Majorie Sweeting, a karst geomorphologist from Britain, conducted a two month programme of hydrological studies in collaboration with the GSD. (Dr. Sweeting was assisted by Brian McGrath in the field work involved.) These studies culminated with the publication of a report; *"Hydrogeological Observations in Parts of the White Limestone Areas in Jamaica, B.W.I."* (Sweeting, 1956) which was to prove seminal for future work on the karst hydrology of the island, and together with additional publications (Sweeting, 1957; 1958), stimulated a wider interest in Jamaican karst and caves.

(b) The Jamaica Caving Club: The creation of the University College of the West Indies (now the *University of the West Indies*) in 1948, brought to the region, for the first time, an institution of higher education which sought to attract academics in a wide range of disciplines, including the sciences. The *Jamaica Caving Club* (JCC), formed in 1958 by a group of cavers (initially headed by Dr. Allan Cunningham, a mountaineer), was centered at the University. Under the leadership of Dr. Ronald Read, Professor of Mathematics, the club became a focus for visiting cavers and associated academics. The Caving Club's membership was drawn from the University staff and students, together with other interested individuals (principally professionals working for Jamaican Government bodies). The Club organized a programme of week-end "expeditions" during which many of the caves more accessible from the University in Kingston were explored. Curiously, at this time, little interest was shown in preparing detailed records of these explorations, or mapping the caves. Rather, "caving" was seen by most members, solely as a recreational activity. The

then existing cave records and surveys, accumulated by McGrath and his associates at the Geological Survey Department appear to have been largely unknown to the Caving Club group. Many of the original McGrath cave surveys were only discovered by the author in 1976, in the records of the Geological Survey Department , during his research for *Jamaica Underground*; (Fincham, 1977). Nevertheless, the early days of the Caving Club were embellished by several major discoveries. In 1958, entry was gained to the underground course of the Coffee River near Auchtembeddie in Manchester, and a spectacular river passage followed upstream through several boulder-falls for over 2700m. The rocks of the underground river bed were found to be eroded into contorted solutional razor-edged forms, later to be described by Aley (1964), as *echinoliths*. In 1964 the Club visited some caves reported at Jackson's Bay, on the southern side of Portland Ridge in Clarendon. This site had previously been visited by McGrath in 1955, and recorded as *Olive Park Caves*. Partial surveys of areas around Entrances #1 and #3 were subsequently found in the fieldbooks (Fincham, 1977). Initial explorations at this site extended over a period of three years, culminating in the publication of a plan of the **Jackson's Bay Cave** in 1966. In 1969 the author, a biochemist and caver from Britain, was recruited to the Faculty of the UWI and had the opportunity to work with the Caving Club until leaving the island in 1985. During this period a computerized data-base for recording of the caves of the island was developed leading to the publication of *Jamaica Underground* (Fincham,1977) which sought, for the first time, to provide a comprehensive listing and description of the known caves, then numbering some 960 sites. The initial data-base for *Jamaica Underground* was prepared using punch-cards and processed on an IBM 1620 main-frame computer. The final output for publication came from the University IBM-360 System using a line-printer, unfortunately without any lower case character capability! Since its establishment in 1956 the Jamaica Caving Club has provided both a local outlet for recreational caving activities and a nexus for Jamaican cave studies. The organization and membership of the Club has fluctuated greatly with the availability of individuals with caving experience. The current Club organizers can usually be reached through the Departments of Geology/Geography, at the University of the West Indies, Mona, Kingston 7.

(c) ***The Expeditions:*** In addition to the explorations undertaken by JCC and GSD personnel, knowledge of the island's caves has been greatly enhanced by a series of caving *expeditions*. Most of these visiting cavers originated in the United Kingdom (Leeds University Expedition, 1963; Karst Hydrology Expedition, 1965-66; Bristol University, 1967, 1969 and Liverpool University, 1977) The earliest such visit was made by a party from the U.S. National Speleological Society (NSS) in 1958 and the NSS was again the sponsor for the series of *Jamaica Cockpits Project* expeditions of 1985-1988. Frequently, these visitors have been responsible for major explorations, particularly of some of the deeper sections of caves and sinkholes where their superior experience and equipment has proved valuable. The background and achievements of each of these expeditions is briefly summarized below:-

The NSS Expedition (1958): This appears to have been the first visit to the island by

an organized party of cavers, and was made in collaboration with the GSD. The most notable contribution of this expedition was the exploration of the 230m deep pit (**Dunn's Hole**) near Stewart Town in Trelawny, being perhaps the first exploration of a deep, vertical cave ("sinkhole") in the island. In addition to this descent the party also visited **Windsor Cave** and several hitherto unrecorded sites on the south coast (White & Dunn, 1962; White, 1962).

Probably the first descent of a sinkhole in Jamaica was that made by Sir Henry Blake, (then Govenor of Jamaica) who, in July 1895, was lowered to the floor of the 80m deep **Hutchinson's Hole** in St. Ann (Ashcroft, 1976). Governor Blake's interest was to seek the remains of persons reputedly flung into the pit by a notorious local murderer; Lewis Hutchinson! (Marshall, 1963; see also; Gascoyne, 1975).

Leeds University Expedition (1963): The Leeds expedition was stimulated in part by the enthusiasm and advice given by Dr. Majorie M. Sweeting. The nine-member party spent six weeks in the island and focussed their activities on the Lluidas Vale polje in northern St. Catherine (Fig. 1). The group made explorations and surveys of 26 caves and sinkholes in and around this area (6,100m mapped), including the complex **Worthy Park Sink** caves, and the **Pedro Great Cave** (Fincham & Ashton, 1967). Hydrological studies included a tracing test (19kg of fluorescein) of the Rio Pedro sink, without result! Also, a series of discharge and water analyses were made at the **Riverhead Cave Rising**, which subsequently stimulated a theoretical treatment of the properties of karst drainage systems (Ashton, 1966). Outside of the Lluidas Vale area, the party explored and mapped the 2,600m **Rock Spring Caverns** and the associated **Dog Hole** system. On reflection, the 1963 expedition was ambitious for its time and perhaps a harbinger of the host of international caving expeditions which have today become almost commonplace.

Karst Hydrology Expedition (1965-66): Originally, this party had planned a visit to Puerto Rico, but after discussion with the members of the 1963 Leeds party, they decided instead on Jamaica. This five-man British-Canadian expedition spent a total of 8 months in the island and explored and mapped over 29,000m of cave passages, much being new exploration! (Livesey, 1966). Much of their work was focussed on new explorations of the Cave River, Mouth River and Quashies River systems, although surveys were also made of the previously explored **Winsor Great Cave** and **Coffee River Cave**. The first exploration of the waterfall shafts of the **Quashies River Cave** and the 116m free cable ladder descent of the **Asuno Hole** are both "classic" exploration accounts (Livesy, 1966; Boon, 1977). In addition to their exploration and mapping, the party conducted a major series of water traces, using both dyestuffs and lycopodium spores. The drainage of the Cave River and Quashies Rivers to the **Dornock Head Rising** (the source of the Rio Bueno) and the Mouth River to **Fontabelle Spring** drainage were established for the first time (Brown & Ford, 1968).

Bristol University Expeditions (1967, 1969): The 1967 party comprised 12 members and focussed their work on the area around Maldon and Maroon Town in St. James. An

extensive and ambitious programme of water tracing, karst hydrology and geomorphology was undertaken, together with the exploration and mapping (~6,700m) of the caves of the area (Smith et al, 1969a). In the cave exploration category, the party made a detailed study of the underground course of the **Tangle River**, from its sinks near **Peterkin Cave**, through **Rota Cave** and **Rota Sink** and at its eventual rising at Deeside some 6km distant. The intermediate course of this river, remains one of the more tantalizing problems of Jamaican cave exploration. During 1969, some cavers from the 1967 group returned to Jamaica and made significant explorations in some other areas of the island, notably of the 1,600m long complex at **Cabbage Hall**, in Clarendon and the **Mafoota River** system in St. James.

Liverpool University Expedition (l977): This five man party spent six weeks in the island based in the Troy area of Trelawny. The major cave exploration was the discovery and survey of the complex and partially flooded **Still Waters Cave** (3350m), near Accompong (McFarlane, 1980). A geomorphological study was made of karren relief in selected areas differing in average rainfall, and a survey of some bat-cave sites was also conducted.

NSS Jamaica Cockpit Project (1985-1988): In 1985 a party of nine cavers from the US initiated a project (The NSS Jamaica Cockpits Project) to explore the karst and sinkholes of the interior of the little-known Cockpit Country region. The party was based at Quick Step, in Trelawny on the southern fringe of the area and was assisted by local guides and JCC members. The 1985 party explored 22 pits and caves and completed the mapping and exploration of the 1750m long **Marta Tick Cave** (Baker et al., 1986). Further expeditions to this, and adjacent areas, were made in 1986 and 1987 (Baker, 1987). Over 20 additional sinkholes were explored, many of 70-80m in depth, but significant lateral development was generally lacking (Canter, 1987). In 1988 an NSS party again visited the island and made some explorations into the difficult terrain of the John Crow Mountains in the east of the island. This highly fissured range of limestone hills rises to about 1,000m and gives rise to numerous streams and rivers on its eastern flanks. However, no significant caves were located.

COMMERCE AND CONSERVATION

The arrival of the Spanish in Jamaica in 1509 opened a period of some 300 years of colonial rule of the island, with the Spanish control being supplanted by the British in 1655. Sugar became the basis of commerce, and the labour was provided through the importation of Africans as slaves for work on the European owned and controlled sugar plantations which expanded to occupy most of the arable level areas of the land (Williams, 1970). Frequently these cane-field areas are closely surrounded by regions of tower karst containing obvious caves in their fringing cliffs. Many such caves house substantial bat populations and probably then, as today, the bat guano provided a source of fertilizer for the small farmer. Whether such guano deposits were exploited by the plantation owners or their slaves for fertilizing vegetable plots is not recorded, but appears likely. Nevertheless, Ja-

maican folk traditions frequently associate caves with "duppies" (ghosts) and such strongly held superstitions may have inhibited the widespread exploration of caves by local people. Long (1774) in his "History of Jamaica", provides a description of the masonry dams and sluices installed within the **Riverhead Cave**, St Catherine, which were employed to provide water to an indigo washing facility operated close to the cave entrance and beside the usually dry bed of the Black River (See; Shaw, p. **39**). Although caves abound throughout the island, it is surprising that references to them in the writings of the 17th and 18th century are sparse.

In more recent times caves which contain bat guano deposits (Cousins, 1903) have been worked by local farmers for fertilizer and a few other caves have been exploited as water supplies (possibly of dubious quality) and as local tourist attractions. This latter activity has been sporadic in the past, with several caves being "shown" to passing travellers by local persons (e.g., the **Windsor Great Cave** in Trelawny). Some sites, notably the **Runaway Bay Caves** ("Green Grotto") appear to have been active, if not commercial, tourist attractions since the mid to late eighteenth century (Zans, 1960). More recently, the **Athenry Estate Caves** in Portland have been developed under the name of **Nonsuch Caves** as a show cave site. At the present time, caves in the island have not been developed as tourist attractions through government sponsored agencies, although some minor sites are now being exploited by local entrepreneurs (e.g., the **Braco Cave** in Trelawny, which attracts passers by under the title of "Arawak Cave".) These caves are certainly not amongst the more spectacular to be found in Jamaica, but many of the other suitable caves are commonly difficult of access (e.g., **Wondrous Cave**, St. Elizabeth) or are located well away from the more usual tourist areas and have not been "developed" for visitors (Frank, 1973). However the, **Roaring River Cave** in Westmoreland has apparently recently been opened as a tourist site.

Possibly, Jamaica, relying heavily on its income from tourism, needs to look more closely at the potential value of developing show caves as alternative tourist attractions and could take example from **Harrison's Cave** in central Barbados, a model show cave development pioneered by the Barbados government "Caves Authority". While the development costs may be high, once such a project is completed the site becomes a permanent national resource and, in certain cases, such "development" has proved to be an effective way of promoting cave conservation, although in the hands of the inexperienced developer, such commercialization can become a refined form of vandalism.

In the future, it is likely that conflicts between cave conservation and industrial and urban developments (water supply, waste disposal, quarrying, commercialization, mining etc.) will become increasingly important. Such problems are evident in the continuing urban development of Hellshire Bay ("Kingston's Twin City") on the honeycomb limestones of the east Hellshire Hills in St. Catherine. Industrial and urban impacts on karst water supplies in the more rural areas have been documented. Sugar industry waste has been implicated in serious water pollution problems at Black River in St. Elizabeth (Wright, 1972); Bog Walk in St. Catherine (Fincham & Ashton, 1967); Wakefield in Trelawny (Fincham, unpublished observations). Contamination of a local water supply at Maldon in St. James was noted by Tratman (1969).

While much has been accomplished in the recording and study of the caves of Jamaica together with their associated hydrology, geomorphology, archaeology and biology, much remains incomplete or unexplored. Public awareness and planning in the evaluation and control of incipient karst-related environmental problems requires strengthening. An integration of the Caving Club expertise and knowledge within existing national structures (The National Trust, the UWI and the Department of Mines and Geology), will be needed if these complex matters are to be wisely addressed.

JAMAICAN SPELEOLOGY

(a) Organization: The development of speleological studies in Jamaica is immature. There is presently no *Caves Authority* or other government-sponsored, or academic speleological organization in the island to represent caving and conservation interests, despite the very large number of caves and their actual or potential impact on the community. (However, the Jamaican National Trust has recently proposed the establishment of a number of National Park areas which would include parts of the Cockpit Country and also Portland Ridge. The Trust has also shown active interest in the conservation of cave sites). It is perhaps notable that, notwithstanding the extensive limestone areas of Jamaica, the UWI Departments of Geology and Geography have generally failed to develop karst studies as a major theme for research. While the Jamaica Caving Club, has experienced the periodic fluctuations in support and membership which are common to clubs of this type, it nevertheless has served as a focus for caving in the island and, in particular, the club has worked closely with the several groups of visiting cavers and speleologists who collectively have done much to develop the existing knowledge of the island's caves.

(b) Karst morphology studies: Accounts of Jamaican caves and their associated karst landforms are few. The pioneer hydrogeological and geomorphological studies of Jamaican karst areas (Sweeting, 1956; 1957; 1958) have served to establish the Jamaican Cockpit Country as a "type area" in tropical karst geomorphology. Versey (1959) provided a general review of the Jamaican karst and during the early 1960's, Aub (1969a,b) made detailed studies of a sinkhole karst area in northern Clarendon, although much of this latter study remains unpublished. Day (1976), and Brook & Hanson (1986) studied the morphology and hydrology of karst depressions in St. Ann, and each of the expedition groups have contributed to such studies (Drew, 1969; Smith, 1969b; Smith et al, 1972; Brown & Ford, 1973). Wadge & Draper (1977a,b) made some preliminary observations on tectonic and lithological factors in Jamaican speleogenesis and a detailed structural study of the caves of the Jacksons Bay area (Figure 2) of Clarendon was published in 1979 (Wadge et al., 1979).

(c) Hydrology: In the area of hydrology, Jamaica has provided an important proving ground for the development of water-tracing techniques suitable for tropical karst, with most of the visiting parties making their contributions (e.g., Ashton, 1966; Atkinson et al., 1973; Smart and Smith, 1976). In particular, these studies served to highlight technical

problems in the use of fluorescent dyestuffs under tropical conditions. Today, the broad picture of drainage patterns in the Jamaican karst is well established, although a few major systems (e.g., **Gourie Cave** in Manchester and **Lowes River Sinks** in St. Ann) await detailed study. The principal Jamaican karst drainage systems established by water tracing techniques are listed in Table 1.

Table 1
Jamaican Karst Drainage Tests

Sinks	Rising(s)	Distance (km)	Test Method*	Reference
Blue River	Pear Tree Bottom	27	R	Smart & Smith,(1976)
"	Laughlands Great River	20	R	Smart & Smith,(1976)
"	Roaring River	25	R	Smart & Smith,(1976)
Browns Town area	Pear Tree Bottom	3-5	F & R	Day, (1976)
Cave River	Dornock Head	21	L	Brown et al.,(1973)
Hectors River	Coffee River	4	F	Liversey, (1966)
Maroon Town area	Deeside Risings		L	Drew, (1969)
Mouth River	Fontabelle Spring	11	L	Brown et al.,(1973)
Nassau Valley area	Elim & Bogue Springs	2-6	L	Drew, (1969)
Quashies River	Dornock Head	14	L	Brown et al.,(1973)
Worthy Park	Black River	14	P	Smart & Smith,(1976)

* F: Fluorescein. L: Lycopodium spores. P: Photine CU. Conc. R: Rhodamine.

(d) Biospeleology: Studies of cave biology in Jamaica have shown the island to have several interesting endemic cave dwellers (Peck, 1975a), including crabs and crayfish (Hartnoll, 1964a,b), bats (Goodwin, 1970; McFarlane, 1986) and a species of the Onychophorian; *Peripatus* known only from a single cave site (Peck, 1975b). Other records of cave invertebrate collections include those of Bowman (1976); Darlington (1964); Holsinger (1974); Muchmore (1984); Peck (1972); Rambla (1969) and Stock (1983).

Currently, some 15 species of cave-dwelling bats have been recorded from Jamaica (McFarlane 1986), with the large colonies present in the **Swansea, Oxford, Windsor** and **St. Clair** caves being the principal focus of collections. St. Clairs' "Inferno Passage" bat population has been a frequent source of specimens for collectors from North America. While current cave bat populations do not appear threatened, McFarlane (1986) casts a note of warning in suggesting that; *"Legislation to protect some of the more important caves .... would serve to focus official attention and monitoring on these sites, ... "*. Existing records of Jamaican cave bat species and populations are limited and a wider-ranging survey, which would permit an assessment of environmental stresses, is needed.

A topic related to the exploration of guano caves is that of histoplasmosis (Frankland, 1974). Although this fungal infection is well known from caves in Puerto Rico (Zamora, 1977); prior to 1978 no clinical case of the disease had been recorded from Jamaica. In January of that year, 24 cases of pulmonary histoplasmosis were diagnosed in a single party of 27 persons exploring the **St. Clair Cave** (Fincham, 1978). Subsequent studies of histoplasmin sensitivity amongst a group of *cavers* and *non-cavers* resident in the island,

showed that *Histoplasma* exposure appeared to be restricted ***solely to the cavers*** (Fincham & DeCeulaer, 1980). These observations have lead to the proposition (Fincham, 1978), that contraction of histoplasmosis by cavers was as likely to occur through exposure in wet tropical bat caves as in the dry dusty sites typically referenced in the medical (and caving) literature (Washburn et al, 1948, Frankland, 1974).

ARCHAEOLOGY - PALAEONTOLOGY

Caves occur throughout the limestone areas of the island and some have certainly been utilized by man since the earliest settlement of the island. Explorations of the coastal caves at **Jacksons Bay** in south Clarendon have consistently revealed Amerindian (Arawak) pottery shards and bones, suggesting the use of the caves for burial rites and, possibly for domestic purposes; collection of water, shelter etc. (Miller, 1932).

The **Jacksons Bay Caves**, together with other sites, also contain Arawak Indian petroglyphs carved into stalagmites in some entrance areas. However, "cave art" other than such rock carvings, is uncommon in Jamaican caves with the **Mountain River Cave** rock shelter at Guanaboa Vale in St. Catherine (now protected and managed by the Jamaica National Trust) being the only known site of Arawak Indian rock paintings in the island. A close examination of the inner chambers and passages of caves, such as those at Jackson's Bay, has failed to provide evidence for Amerindian cave paintings (Fincham, unpublished observations) and it appears that these people used only the entrance chamber areas. The lack of paintings within the caves is somewhat remarkable, since such work is not uncommon in the inner chambers of caves in both Cuba and Hispaniola (Jimenez, 1975). While most of the Amerindian cave sites appear to be coastally located, some notable petroglyphs occur in inland caves, for example at **Pantrepant Cave** in Trelawny, **Chesterfield Cave** in St. Ann and at **Man Cave** in St. Mary.

In most cases of presumed cave use by Jamaican Amerindian people we have no reliable chronological data from which we can determine when these sites were in use. An exception to this has been some recent carbon dating of bone recovered from the **Jackson's Bay** area (McFarlane, 1989; personal communication). A human bone fragment provided a ^{14}C date of 710 BP ±60 This date is of special interest when taken together with the dating of a marine shell (795 BP ± 70) excavated from below a 2m deep deposit of fossil bat guano in an entrance chamber of the Jackson's Bay Cave, and of the presence of Arawak pottery shards associated with (now dry) cave pools. The Jackson's Bay area today receives an average annual rainfall of less than 40 cm and the existing cave-dwelling bat populations are sparse, reflecting the arid nature of this region. It appears likely that the accumulation of the guano deposits (noted above) may reflect a period of higher rainfall contemporaneous with Amerindian use of the caves for water collection and burial, if not for habitation. That some caves were used as ritual burial sites by the Arawaks appears probable from the recovery of a human radius and ulna, associated with a chared pottery shards and the presence of fragments of cassava griddles and of Amerindian skulls in some of the Jackson's Bay area caves.

The principal international motivations and interest in palaeontological research in Jamaica have come from earlier studies of the extinct rodents and the unique primate remains (*Xerothrix*). Cave-related research in Jamaica has focussed principally on the fossil finds of Anthony (1920, 1924), at the **Wallingford Cave** sites in St. Catherine (Koopman & Williams, 1951; Williams & Koopman, 1952), and McFarlane & Gledhill, (1985) have recently reviewed these data. Other recent reports include those of MacPhee et al., (1983); studies at **Long Mile Cave,** Trelawny, MacPhee (1984); Ford (1984); Goodfriend & Mittener, (1987); Ford & Morgan (1988) and MacPhee et al, (1989).

JAMAICAN CAVE EXPLORATION

(a) Current status: It is probable that most of the major river-cave systems of the island have now been identified and at least partially explored, although there are numerous smaller caves and sinkholes which still require detailed investigation and survey. The most extensive caves are found around the Central Inlier (Figure 1) where they are associated with the major drainage systems. The numerous vertical shafts ("Sinkholes") which occur throughout the Cockpit Country and Dry Harbour Mountain areas, commonly bottom-out in narrow joints or debris chokes with little lateral development (Canter, 1977). In the southern coastal areas, large horizontal caves such as are found in Portland Ridge, show ancient solutional features suggesting the influence of sea level changes (Wadge et al, 1979).

(b) Documentation: Documentation of the caves is a continuing activity, and while a listing of over 950 sites was originally published (Fincham; 1977), the existing data-base includes over 1200 sites. This *Jamaica Underground* data base (Macintosh, Filemaker II_) is maintained by the author and cavers making new discoveries in the island are urged to provide details for updating of the files.

A listing of the currently longest and deepest caves in the island is provided in Tables 2 & 3. It must be noted here, that in the case of "longest" the data are based on surveys which vary greatly in their detail. Thus, for example, the recent survey of **Marta Tick Cave** (Baker et al, 1986) by an NSS party is a model of thoroughness and records a length of 750m, whereas the 3,350m length recorded for the **Jacksons's Bay Cave** complex, based on the 1963-65 survey by the JCC, almost certainly excludes substantial lengths of minor passages. General accounts of Jamaican caves include those of, Peck & Kukal (1975) and Waltham & Smart (1975).

Table 2
Jamaican Caves over 1000 m in Surveyed Length.

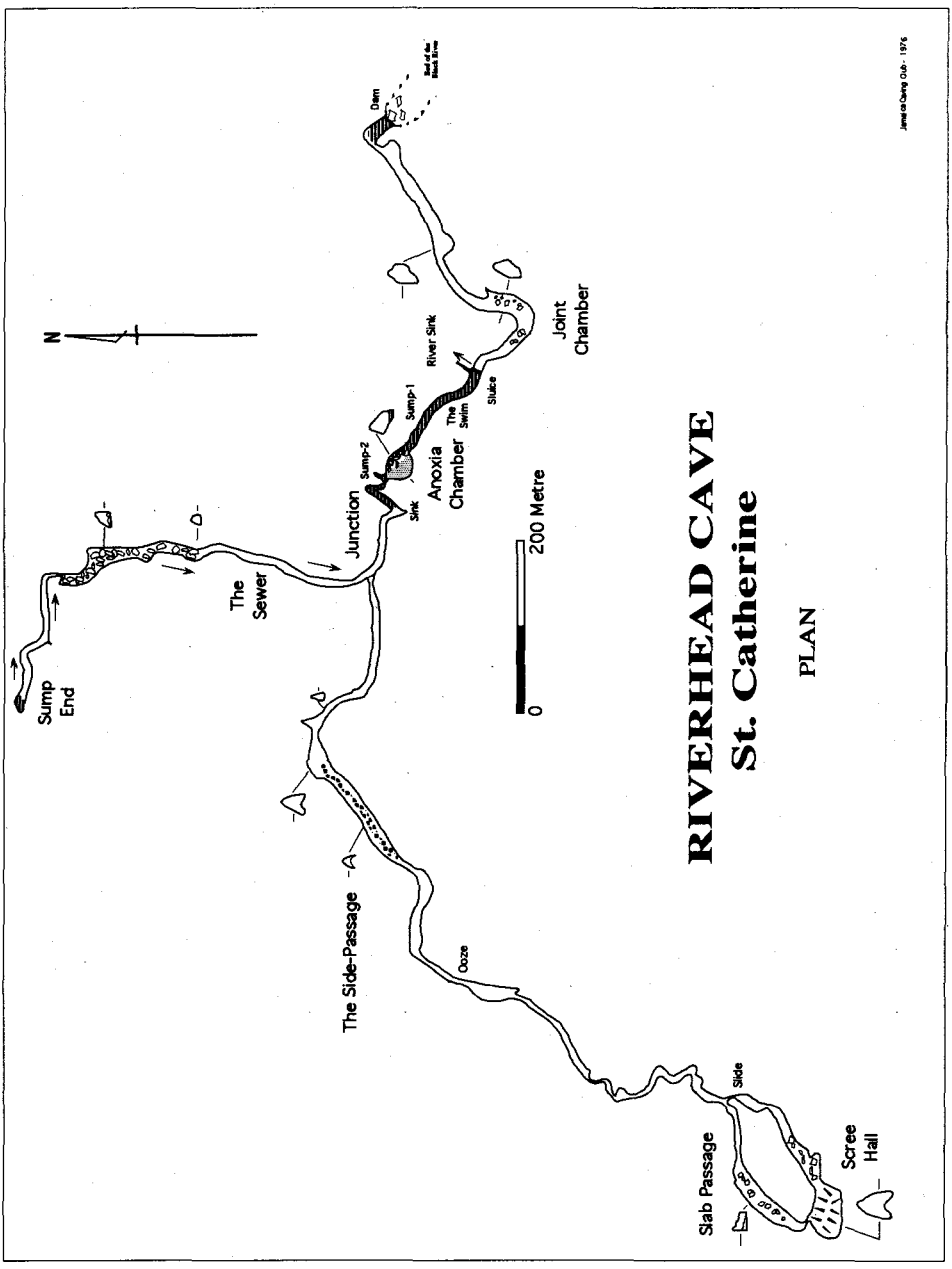
Cave	**Parish**	**Length m.**
GOURIE CAVE	Manchester	3505
JACKSON'S BAY CAVE	Clarendon	3353
STILL WATERS CAVE	St. Elizabeth	3353
PRINTED CIRCUIT CAVE	Trelawny	3219

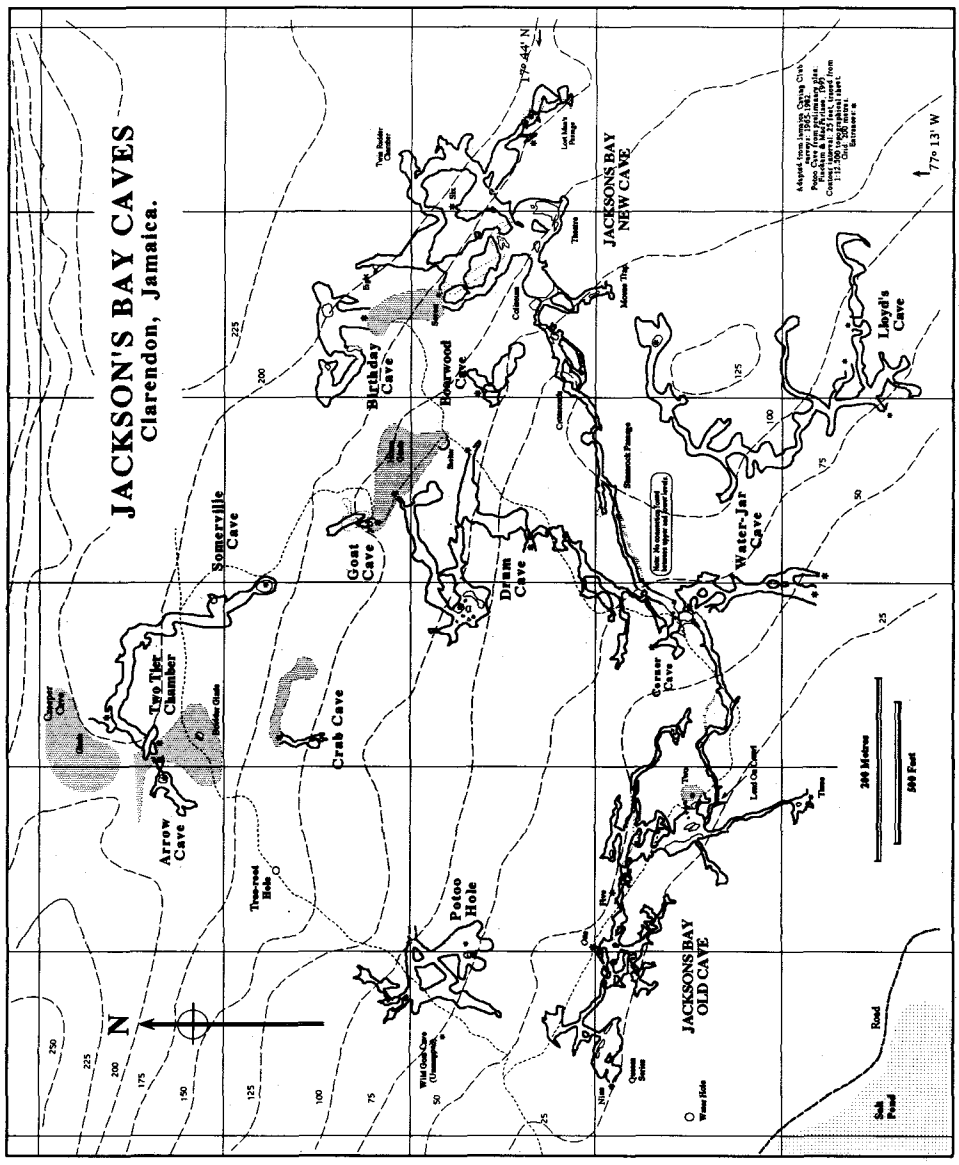
MOUTH MAZE	Trelawny	3188
WINDSOR GREAT CAVE	Trelawny	2978
St. CLAIR CAVE	St. Catherine	2896
COFFEE RIVER CAVE	Manchester	2801
ROCK SPRING CAVERNS	St. Mary	2591
CAVE RIVER: Noisy Water - 2	St. Ann	2475
RIVERHEAD CAVE	St. Catherine	2438
BRISTOL CAVE	Trelawny	2261
ME NO SEN CAVE	St. Elizabeth	1981
DOG HOLE	St. Mary	1969
CABBAGE HALL CAVERNS	Clarendon	1585
RUNAWAY BAY CAVES	St. Ann	1524
GOLDING RIVER CAVE	Manchester	1490
THATCHFIELD GREAT CAVE	St. Ann	1402
FALLING CAVE	St. Elizabeth	1294
SWANSEA CAVE	St. Catherine	1170
HARTIES CAVE - 2	Trelawny	1058
QUASHIES RIVER CAVE	Trelawny	1029
LLOYDS CAVE	Clarendon	1003

Table 3
Jamaican Caves of 80 m Depth and Above

Cave	**Parish**	**Depth m.**
DUNN'S HOLE*	St. Ann.	229
MORGANS POND HOLE	Manchester.	186
THATCHFIELD GREAT CAVE	St. Ann.	177
VOLCANO HOLE	St. Ann.	158
NEW HALL CAVE	Manchester.	151
ASUNO HOLE	St. Ann.	137
SPLOOSH POT	Trelawny.	125
WRIGHT'S HOLE	Manchester.	119
EVERLASTING HOLE	Manchester.	116
QUASHIES RIVER CAVE	Trelawny.	111
HUTCHINSON'S HOLE	St. Ann.	98
DADDY'S SINK	Clarendon.	94
GOURIE CAVE	Manchester.	91
MURROW HOLE	Trelawny.	91
HOLE-IN-THE-WALL PIT	Trelawny.	87

* The depth quoted for Dunn's Hole is somewhat artificial, since it relates to the overhanging cliff which forms the northern aspect of the sinkhole.


RIVERHEAD CAVE
St. Catherine
PLAN
N
0
200 Metre
Sump End
The Sewer
Junction
Sump-2
Sink
Anoxia Chamber
Sump-1
The Swim
River Sink
Sluice
Joint Chamber
Dam
The Side-Passage
Ooze
Slide
Slab Passage
Scree Hall


JACKSON'S BAY CAVES
Clarendon, Jamaica.
JACKSON'S BAY NEW CAVE
JACKSON'S BAY OLD CAVE
Somerville Cave
Goat Cave
Birthday Cave
Ringwood Cave
Drum Cave
Water-Jar Cave
Lloyd's Cave
Arrow Cave
Two Tier Chamber
Crab Cave
Potoo Hole
Tree-reed Hole
Water Hole
Road
N
17° 44' N
77° 13' W
200 Metres
500 Feet

WANDERING WELL	Trelawny.	87
PENITENTIARY - 3	St. Catherine.	87
JEZEBEL HOLE	Trelawny.	85
BREADNUT HILL HOLE	St. Elizabeth.	84
MENOCAL'S GLORY HOLE	Trelawny.	83
CRESCENT PIT	Trelawny.	80

(c) Exploration: It is not possible within the confines of this chapter to present any extensive descriptions of Jamaican cave explorations. However, notes on some selected explorations, having some unusual features, are given below.

Riverhead Cave, St. Catherine. While this cave had been well known (Long, 1774), the penetration of the system (Figure 3), beyond the "Sluice" water diversion was inhibited both by the deep upstream canal and sump, and by "foul air". In 1971 a JCC party lowered the sump water level and was able to swim into a farther chamber (terminated by a second sump), only to be severely affected by anoxia. (Subsequent gas analysis showed levels of oxygen: 13.9%, and carbon dioxide: 2.75%). It was thought that the foul air originated by pollution of the river with sugar washing waste from the Worthy Park factory in Lluidas Vale. Further exploration lead to the passing of the second sump and the mapping of the Side Passage, but upstream (The Sewer) exploration was halted at the foot of a boulder-fall in a lofty chamber where progress was again prevented by the foul air. An attempt to pass this point was made using scuba tanks, but the end of the cave was not reached. An extreme drought in September 1976 finally provided conditions which permitted JCC cavers to explore beyond the boulder fall to the limit (Sump End) of the upstream river passage. The acute foul air problem encountered in cave passages of such large volume makes these explorations of particular interest and has yet to be fully explained.

The Cave River System. The Cave River of St. Ann is notable for severe floods which frequently result in the inundation of the lower parts of the Cave River valley. Prior to the Karst Hydrology Expedition of 1965-66, the underground course of the Cave River was unknown. The expedition party (Livesey, 1966) made a notable contribution in their detailed exploration and mapping of this complex of caves culminating in the ladder descent of the Asuno hole (137m) and the successful water-tracing of the underground river to the Dornock Head rising. Sawkins (1869), in the Geological Survey Memoir, had wrongly interpreted the surface topology and had presumed the Cave River to be the headwaters of the Pedro River/Rio Cobre system).

Quashies River Cave. The Quashies River goes underground in an impressive and locally well known sink. The river has a steep gradient and drains a substantial area, leading to massive flooding in rains. In the underground river passage (5x20m) the walls have a "polished" appearance reflecting the power of this flow. A descent of the river passage requiring both swimming in the strong current and traversing above the waterfall

shafts, has provided a caving experience which has become accepted as a "classic" for the island (Livesey, 1967; Waltham, 1976; Boon, 1977).

Jacksons Bay Caves. The complex of caves making up the Jackson's Bay system located in the arid limestone hills of Portland Ridge in southern Jamaica has proved remarkable from several point of view. In total these caves comprise somewhat over 7,000m of fossil phreatic caverns mostly located less than 50m above present sea level (Figure 2). Speleothem dates for the Main Cave suggest a minimum age for its formation of 250,000 years BP (Wadge et al., 1979). Jamaican cavers first became aware of this system in 1964, as the result of a note in an unpublished manuscript in the Library of the Institute of Jamaica, although archaeological interest in these sites was shown as early as 1895 by Duerden. During 1964-65, the JCC carried out exploration and surveys of the main passages of the Jackson's Bay Cave (Ashcroft, 1969). The bush-covered terrain of the Portland Ridge hills makes surface navigation and entrance location extremely difficult. However, subsequent explorations revealed a second complex of caverns (**Somerville Cave, Drum Cave, Water Jar Cave)** overlying parts of the **Jackson's Bay Main Cave**, but apparently unconnected with it. These later explorations included detailed surface mapping and resulted in the location of many new sites (Wadge et al., 1979). This whole system is remarkable for its extensive phreatic caverns, complex morpholgy, unique situation and splendid speleothem displays.

(d) Cave diving: Cave diving activities in Jamaica have been few, although the 50-60m deep blue-hole (**God's Well**) in south Clarendon has often attracted attention from non-caver scuba divers, sadly with tragic results (Nicholson, 1985; Knutson, 1986). The multi-entrance flooded complex; **Two Sisters Cave** in the East Hellshire Hills has also attracted some scuba-diving interest. The most significant "cave dive" exploration to date was made in the **Worthy Park III** cave in 1981. A narrow descending, downstream passage leads into a long cavern with silt banks, ending after 75m in a deep sump which remains closed, even in drought. The sump (80m long and 10m deep) was passed by a JCC - Jamaica Sub-Aqua Club diving team to a further 140m of dry passage ending in a second sump. Exploration beyond this point has not been made, but it is thought that a linkage with the caverns lying beyond the upstream (Sump-End) pool of the Riverhead Cave (see above) is possible by this route.

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JAME NA JAMAJKI IN NJIHOVO RAZISKOVANJE

Povzetek

Jamajka, otok v Velikih Antilih, obsega 11.420 km^2. Dve tretjini otoka sestavljajo zakraseli, tektonsko prelomljeni apnenci eocenske in miocenske starosti. Za notranjost je značilen t.im. "cockpit" kraški relief (depresije nepravilnih oblik in vmesni stolpi), ki ga tu in tam prekinjajo kraška polja. Največje apnenčevo gorovje dosega višine 2.300 m.

Za hidrologijo Jamajke so značilne reke ponikalnice, ki ponikajo v srednjem delu otoka in napajajo kraške izvire vzdolž Duanvale prelomnega sistema. Več vodnih zvez je bilo dokazanih s sledenji, med njimi do razdalje 27 km.

Glavna vzpodbuda za raziskave kraških jam, ki jih je organiziral po vsem otoku Geological Survey Department, je bila potreba po guanu kot gnojilu v prvih letih II. svetovne vojne. Ta oddelek je preučeval tudi vodne razmere. 1958 je bil na univerzi ustanovljen Jamaica Caving Club, ki je že v prvih letih dela odkril velike jamske sisteme. Med 1969 in 1977 so s pomočjo računalnika uredili jamski kataster in ga tudi izdali v tiskani obliki "Jamaica Underground". K poznavanju podzemlja na Jamajki so precej pripomogle tudi tuje speleološke odprave: 5 članov britansko-kanadske odprave je bilo na otoku 8 mesecev in v tem času raziskalo, izmerilo in izrisalo načrte 29 km jamskih rovov. Danes vsebuje kataster podatke o okoli 1200 jamah. Iz tabel največjih jam na Jamajki je razvidno, da je vsega skupaj 23 jam, daljših od 1000 m, najdaljša je 3505 m dolga Gourie Cave. Več kot 80 m globokih je 21 jam z 229 metrsko Dunn's Hole kot najglobljo.

V novejšem času so v ospredju morfološka, hidrološka in biospeleološka preučevanja. Morfologijo so preučevali tudi svetovno znani krasoslovci (Sweeting, Ford) in danes je kras na Jamajki znan kot tipični tropski kras. Na Jamajki je znanih 15 vrst jamskih netopirjev. Najpomembnejša tema biospeleoloških raziskovanj pa je bolezen histoplasmosis, pri čemer je prav na Jamajki prišlo do pomembnih odkritij. S paleontološkega in arheološkega vidika je treba omeniti raziskave izumrlih glodalcev in ostankov edinstvenega primata Xerothrix ter indijanskih kultur.