

VOLCANOKARST IN THE CULTURE AND LANDSCAPE OF EASTER ISLAND

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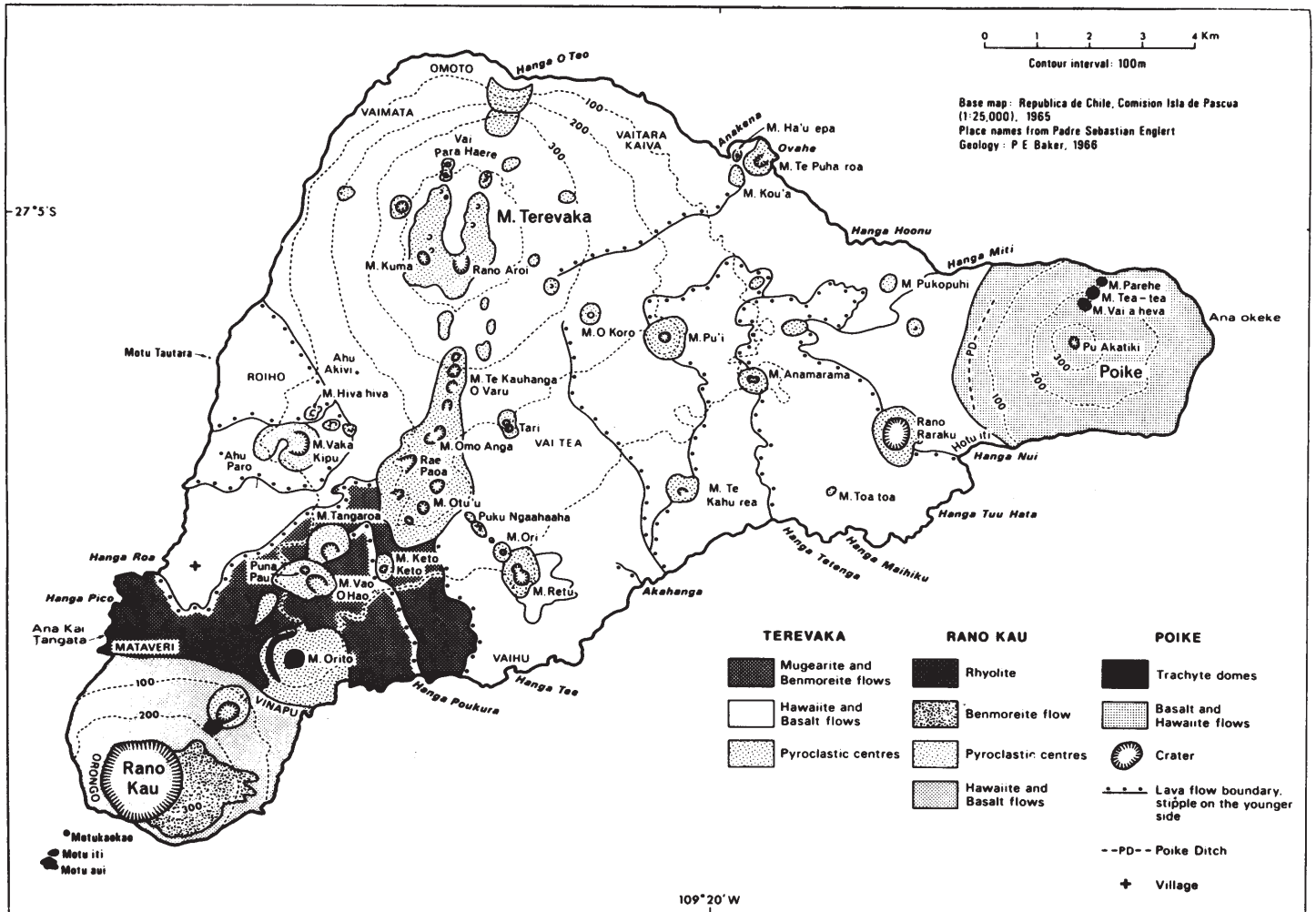
ABSTRACT

Volcanokarst is intimately interwoven with the human history of Easter Island. While the caves have been a focus of some archaeological investigation, they have been little studied in their own right. The island is entirely volcanic, and lava tunnels are well developed in tholeiitic flows which emanated from several vents. The Roiho olivine basalt flow from the small cone of Maunga Hiva hiva is particularly rich in caves. There is limited cave development due to piping of volcanic ash.

INTRODUCTION

In the popular medias as to the archaeologist, Easter Island has long been shrouded in mystery. According to folk memory, one Hotu Matua had a vision which led him to dispatch six scouts from his ancestral home of Marae Renga to look for an "island full of holes." Ever since, caves have added to the enigma of the world's most isolated outpost of humanity, a

place best known for the giant human statues or *moais* which occur in various parts of the island, notably on the temple platforms of *ahus* which fringe the coastline. The first systematic investigations of the caves by Europeans were those of Thompson (1889), Routledge (1919), and Lavachery (1935). A geologist reported further caves in 1937 (Bandy, 1937). A Catholic missionary, Father Sebastian Englert, visited many caves during his years on the island (Englert, 1948). After his



Geological map of Easter Island after Baker et al (1974).

epic Kontiki expedition drifted too far to the north to land on Easter Island, Thor Heyerdahl mounted a prolonged archaeological investigation in the 1950s (Heyerdahl, 1958, 1976, Heyerdahl, et al, 1961). Heyerdahl published a map which recorded the location of 43 caves visited by his expedition, and the probable location of further 17 caves reported by islanders (Heyerdahl, 1958). Other caves were located during geological research in the 1960s (Baker, 1967). A further 30 caves not recorded on Heyerdahl's map were explored in 1976 (Kiernan, 1976). The object of this contribution is to briefly consider the human history of Easter Island and the role caves have played, and to review the extent of the volcanokarst.

The isolation of Easter Island is reflected in an ancient name: Te Pito o te Henua-naval (centre?) of the earth. The Dutchman Jacob Roggenveen, is believed to have been the first European to sight the island on Easter Day, 1722. The stone age Rapanui people were next visited in 1770 by the Spaniard Don Felipe Gonzales. The speedy disappearance of the gifts and stolen items led the Spanish to presume that secret hideaways lay beneath the open landscape. An account by Aguera (1770) noted that "most of the natives . . . dwell in underground caves . . . the entrances to which are so narrow and inconvenient that I have seen some of them introduce themselves in the opposite manner to what is natural, beginning by projecting their feet and the head last." In 1774, Captain James Cook saw few people and thought that the islanders must have been hiding in caves, but his men were refused admittance when they tried to examine the boulder piles which they believed hid the entrances. This network of caves was later dramatically demonstrated to La Perouse when the islanders suddenly appeared all over the barren landscape to greet his ship as if they had been spawned by the earth itself. The visitors were permitted to enter some of the caves. But as the years drew on, the owners of the caves and those who knew their locations, were decimated by outsiders and by internal strife.

Public awareness of the tragic recent history of Easter Island is overshadowed by that of the mysteries posed by its statuary and prehistoric culture. Following internecine strife in his ancestral home, Hotu Matua's small band voyaged to a triangular island 21 x 14 km in extent, with a circumference of 47 km, and an area of 160 km². Their first residence lay in caves at Anakena. Rising to 511 m, at the same latitude as Brisbane (lat. 27°10'S; long. 109°20'W), Easter Island lies on



Carved human skull from an Easter Island cave.

the southern margin of the southeast trades, which blow from October to April and leave the grasslands to bend in waves before more variable winds at other times of the year. The mean annual temperature today is 22°C and 100 mm of rain soaks rapidly into the porous volcanic soil to become accessible only in a few springs, caves and crater lakes, and in a single surface stream.

Since settlement, the island has been converted to grassland, and sheep in particular have done much to change the "heaven on earth" witnessed by Roggenveen and La Perouse's garden, to what Gossett (1938) described as an island whose "whole aspect . . . is one of barrenness, loneliness and dreariness."

Heyerdahl asserts that the first inhabitants were skilled stonemasons who ignored timber and who arrived from South America, perhaps as long as 2000 years ago. This thesis rests upon the pre-Inca style statues and the Inca-like stonemasonry of the Vinapu site on Easter Island, the latter dating from about AD 800. Much of this early construction was dismantled to retrieve building materials during later cultural phases. However, there is considerable cultural unity with Polynesia. Radiocarbon dating indicates that man from southeast Asia had reached the Solomon Islands by 5 kyrs. BP, and New Caledonia and Fiji by 3 kyrs. BP. He reached the Marquesas by AD 400 and extended into the Easter Island, Hawaiian and New Zealand extremities of the Pacific triangle after AD 500. Megaliths remained behind in the Marquesas, Tonga, Easter Island, and also on the coast of Peru. Did some of the South American culture come from the Pacific? Heyerdahl cites a radiocarbon date of AD 380 from Easter Island and recently discovered coral and obsidian eyes which fit some of the moais and appear to be of South American affinity. Perhaps Easter Island welcomed settlers from both east and west.

The people encountered by Roggenveen appeared to comprise two groups. Some were red haired and tattooed, their ears deformed like those of the moais through elongation of the lobes by heavy weights. These people were the Tu'uario and Hotuiti people (variously referred to as the "long ears" or "thin" people) who tilled the thin stony soils. Among them were the Hanauēpe ("short ears" or "fat" people — again depending upon the authority consulted) who fished the seas around Easter Island. While Heyerdahl argues that South Americans were the first migrants, it is generally argued that the "long ears" arrived first. It seems clear at any rate that the short-eared Hotu Matua was part of a second wave. The islanders then dwelt in rush huts, fished, and cultivated sweet potatoes. The existence of the moais implies a high degree of social organization for enormous energies were diverted away from food production.

The carvers were still at work in AD 1470. But in the 17th-18th century, strife broke out, possibly due to diminishing crops during the Little Ice Age (McCall, 1981). Weapons are absent from archaeological deposits prior to AD 1680, but suddenly obsidian spear points littered the ground. The "short ears" resisted the demands of the "long ears" to help clear the soil of rocks, promoting what was probably the only major battle prior to the arrival of the Dutch. Hundreds of skeletons with broken bones and carved skulls attest great violence and are to be found in the caves and elsewhere. The Rapanui fled underground, often using the foundations of their former reed houses for construction purposes in the caves. Food production ground to a halt and starvation took over. The sufferings are reflected in wooden carvings of emaciated figures with

protruding ribs which have been found in this island's caves.

The old deities were of little assistance. Strangers arrived in great ships. Violence met despair and compounded it. The moais were overturned, probably around the 1860s. Now the seasonal arrival of terns became important to the diet of the Rapanui. The tern came to be worshipped. Hereditary kingship was replaced by a system of annual competition to obtain the first egg laid on the islets off Rano Kau coastline. When Europeans first arrived, this new cult of the bird-men was still ascendant. Yet another cultural development was superimposed upon the palimpsest of the island's caves.

Caves were quite vital to the Rapanui economic system, described by Ferdon (1958) as "steal trading" by virtue of which "any available object is insecure as far as its owners is concerned." Ferdon continued: "The secret cave in Easter Island culture represents the one secure place for whatever kind of property an islander wishes to keep. It is not going too far to say that the ownership of secret caves for the hiding of persons and property emerges as one of the most characteristic features of Easter Island culture. In the decadent late period, caves were probably as important to the Easter Islanders in their daily lives as were the famous ahu images in the middle period. Since secret caves or caches may be accidentally found by another, they are guarded by dangerous personal spirits called *akuaku* who have the power to disable or kill any trespasser — the need for some sort of spiritually protected 'warehouse' is a functional necessity for the preservation of family heirlooms and capital assets."

VOLCANOKARST IN THE LANDSCAPE: CAVE EXPLORATION

Thompson (1889) observed that "natural caves are numerous, both at the coast and in the interior of the island." His was the first European party in pursuit of archaeological relics to explore caves on Easter Island (Heyerdahl, 1976). He recognized caves that were "worn by the action of waves" as opposed to others which were "due to the expansion of gasses in the molten lava and other volcanic action." He continued:

"Many caves were reached after difficult and dangerous climbing and were found to contain nothing of interest, while others of traditional importance were inaccessible from below, and we were not provided with ropes and the necessary appliances for reaching them from above. Some of the sea-worn caves are of considerable extent, but generally difficult to access and affording little of interest except to geologists. The caverns produced by volcanic agencies are found throughout the island and some were traced through subterranean winding to an outlet on the bluffs overlooking the sea. They were generally quite dry. The rainwater falling upon the surface occasionally finds its way between the cracks or joints in the solid rock, but these gloomy passages and chambers lack grandeur from the entire absence of stalactites and decorations of carbonate of lime. No glistening and fantastical forms of stalagmitic decorations exist here to excite the fancy and create in the imagination scenes of fairy-like splendour. The feeble rays of our candles were quickly absorbed by the sombre surroundings, heightening the apparent extent and gloom of the recesses."

The archaeology of these caves also drew the attention of Katherine Routledge in 1914, whose party "daily examined such caves and grottoes as came under our notice," but she too

complained of her "inability to reach the most thrilling of the caves, which are halfway up the great sea cliffs," (Routledge, 1919). In her footsteps came a Franco-Belgian expedition in 1934 (Lavachery, 1935).

Many caves were known to the late missionary Father Sebastian Englert. Among a number of notable explorations by Father Sebastian was that of the 400 m long *Ano o Keke* at the eastern end of the island. Father Sebastian's Rapanui housekeeper and her sister-in-law were keen cave hunters who greatly assisted him in his documentation of Easter Island's antiquities. His book on the island recorded the use of caves for residential purposes, for burial and for refuge. He referred also to the:

"Secret caves which were the property of particular families and only the most important persons in a family knew the entrance to their respective secret cave. These served as hiding places for valuable things, such as inscribed tables, rongo-rongo or statuettes. The secret of the exact location of the entrance is buried in the graves with the last survivors of the old times." (Englert, 1948).

Although Father Sebastian had failed to gain access to any of these family caves, the Norwegian party under Thor Heyerdahl which spent several months on Easter Island in the mid 1950s confirmed not only that they existed, but that they continued to be respected and maintained by the islanders. Within such caves the archaeologists found carvings of wood and stone, often wrapped in or sitting upon reed mats, together with some stone containers and skeletal remains of forebears. Other caves contained fish shells; bird, rat and turtle bones, amulets of bone and shells, and needles of human bone. Considerable ceremony was attached to entry into the caves. Even after the ceremonial transfer to Heyerdahl of one cave's contents, the former owner retained the cave itself "in case of war." Indeed, long after burial in the *Hanga Roa* village cemetery had become compulsory, there were still instances of elderly islanders stealing away to die alone in their family caves. Only the few remaining descendants of the "long ears" maintained family caves.

Subsequent archaeological studies to which I do not have access have presumably continued some investigation of caves. However, while caves are abundant and many are easily found, this is not always the case. Small entrances in steep cliffs provide a natural difficulty exploited in the selection of secret family caves. Entrances to other caves used to store family treasures or provide refuge during the fighting, were deliberately hidden:

"Atan . . . pointed straight to the ground at the tips of my toes. I saw there a small flat stone half covered with sand and loose straw, exactly like 10 million others nearby." (Heyerdahl, 1958, p. 226).

Easter Island is characterized by countless billions of scattered rocks, any of which might deliberately cover caves. Although Heyerdahl doubted the veracity of some guides who failed to locate alleged caves, it is as well to remember how frequently cavers manage to lose caves in the bush without the additional obstacle of their being deliberately hidden. On Easter Island in 1976, I was myself extended the utmost hospitality and friendliness by the Rapanui, but on the other hand, there was zero cooperation as far as caves were concerned — indeed, the very existence on the island of *any* caves whatsoever was strenuously denied, even though entrances lay agape for all to

see around the outskirts of the village. Whether the veil of silence was due to a continued desire to protect family caves or perhaps to debunk any suspicion of the old beliefs still being held remains open for debate. Alternatively, it may be noteworthy that on my departure, I was taken aside by armed officials and thoroughly searched. I record the fact not in protest, but in appreciation that the authorities apparently no longer intend to permit the sort of archaeological plundering which has robbed Easter Island of too much of its heritage.

And perhaps before any speleologist risks trampling underfoot the sensitivities of the Rapanui, it may be as well to recount an anecdote recorded by Heyerdahl (1958, p. 210).

"I had said that sometime in the future, it would be possible to find the secret caves and tunnels of the island by going over the ground with a kind of cavity detector. This had made a strong impression on Lazarus. As we rode along, he pointed out several areas in which such an apparatus would be effective because there was supposed to be secret caves under the ground, of which the openings had been lost. He declared with dismay that the first person to bring the apparatus to the island would get rich simply by walking among the houses in the village. A secret cave 300 yards long, which had belonged to one of the last kings, ran underground to the sea from an unknown spot near the most northerly houses. It was found by a man who brought up some gigantic spearheads from the cave, but the aku-akus "bit and pricked him night after night until he died."

Preoccupation with the search for family caves and archaeological deposits has meant that caves have been undervalued as remarkable landforms in their own right. Heyerdahl's (1958) account reflects on the morphology and size of some of the non-secret lava tunnels:

"Later we visited several of these huge caves with room after room like pearls on a string running down through the underworld. Their entrances were all so skillfully walled up that no one could get down through the narrow funnels cut with sharp angles or zig-zags, in which any assailant would be completely helpless. There was water in some of the largest caves; two of them had regular subterranean ponds and right down at the bottom of a third we found a walled well of ice cold water surrounded by a stone pavement and a well built terrace some ten feet high."

Although caves have been mentioned by at least two geological workers on Easter Island (Baker, 1967, Bandy, 1937), the only other paper known to the writer which specifically focusses upon the caves is his own brief review of his limited explorations in 1976, which may have introduced Easter Island to the speleological literature for the first time (Kiernan, 1976). This exploration focussed upon the Roiho flow, the lava flows to the east and south, a small area on the northwest slopes of Rano Kau, and also upon the piping caves of Rano Aroi and sea caves around Hanga Roa. As intriguing as secret caves may be to archaeologists and treasure hunters, they provide only a sidelight to the story of Easter Island and its caves, for the island abounds with more obvious and less sensitive entrances. This is accurately reflected by Heyerdahl's comment that "on the first day, we were in and out of caves from morning to night," and as Gossett (1938) observes, the shore of Easter Island is "honeycombed with caves in the lava."

VOLCANOKARST IN THE LANDSCAPE: THE LAVAS AND SOME CAVES

Easter Island lacks continental rocks. Although conglomerate was recorded by Braun (1924), the material he described is a tuff. But for some calcareous sand at Anakena, the traditional landing place of Hoto Matua, and also at an equally picturesque beach 2 km to the east, the island is entirely volcanic. It is surrounded by oceans 4,000 m deep. The island's geology is described by Baker (1967), Baker, et al, (1974), Bandy (1937) and Gonzales, et al (1974).

The basalts of Easter Island are tholeiitic but range between quartz normative and olivine tholeiites (Baker, et al, 1974). They are low in MgO, but high in T; Zr and total iron. A low K content is also characteristic. Three large volcanoes — Poike, Rano Kau and Maunga Terevaka — stand at the corners of this triangular island. About 70 lesser eruptive centers are known. Much of the coastline comprises high cliffs on the flanks of the cones, but to the south it is formed by a single flow only a few meters thick. Although various caves have been entered both by islanders and visitors, I am unaware of any cave inventory, and the following only scratches the surface of what is already known, but which seems to be mostly unrecorded.

(i) **Poike:** Poike is a stratovolcano from which a K/Ar assay of 3MyBP has been obtained. Poike comprises the oldest section of Easter Island. Trachyte is associated with the parasitic domes of Maunga Vai a heta, M. Tea-tea and M. Parehe, but the northern cliffs are highly porphyritic basalts of hawaiites with plagioclase phenocrysts. Aphyric lavas lie to the southwest. Poike was formerly a separate island. Lava caves occur right around the Poike coastline, the best known lying on the northern side.

Ana o Keke (Cave of the White Virgins; Cave of the Sun's Inclination) lies east of Katiki volcano. Its small entrance lies in a steep sea cliff. This cave contains about 400 m of passages, some of which are narrow and wet. Human remains lie in a dry inner chamber. Young girls were confined in the darkness of this cave to bleach their skin to match the fairness of the gods. Here their religious training included learning to recite from the rongo-rongo, wooden tables with now undecipherable hieroglyphics of which no more than 20 are known. Several girls are reputed to have survived a smallpox epidemic by virtue of their isolation in Ana o Keke, only to die of starvation when there was no one to bring them food.

In this same area lies a residential cave. A spring supplies the water which is fed into the massive mouth of a giant head carved into the rock wall nearby. Other caves and a spring from a deep fissure lie east of Maunga Tea-tea. Further caves occur on the southwest side of Maunga Vai a heva, in the sea cliffs on the southeastern extremity of Poike, and at least one on the island of Marotiri.

(ii) **Rano Kau:** At the western extremity of Easter Island stands Rano Kau. Its impressive caldera of 1.5 km diameter contains the large lake from which this volcano derives its name. Sea cliffs of 300 m mark its western flank. Thin basaltic lava flows are interbedded with pyroclastic material at the base of Rano Kau and are overlain by more differentiated lavas. Benmoreitic flows form the upper caldera wall. These break into flat slabs which were used to construct the Ahu Viahu.

White trachyte and rhyolitic obsidian are associated with a parasitic center on the northeastern slopes, and rhyolites with the "birdman" islands of Motu iti, Motu nui and Motu kao kao. The obsidian of Maunga Ourito and Maunga Otu is generally a clear, greenish brown glass with a conchoidal fracture. Man has scattered the obsidian widely across Easter Island in the form of stone tools.

One of the best known caves of Rano Kau is Haka-Rongo-Manu (Cave of Listening for the Birds). This lies partway down a steep sea cliff below Orongo. During the bird-man phase, it was here the Rapanui waited for the arrival of the first manu tera tern (*Sterna fuscata*) to reach the bird-man cliffs. Still other caves occur around the northeast crest of Rano Kau, and numerous other rumored caves were presumed by Heyerdahl to lie in the sea cliffs, particularly in the Rikiriki-Vinapu area. A number of caves occur on Motu nui, some of which contain human bones. Two were visited by Routledge. In another, Heyerdahl found statuettes, including a red head with a goatee beard.

(iii) **Maunga Terevaka:** Rising to 511 m on the northern corner of Easter Island is the complex fissure volcano of Maunga Terevaka, the island's highest summit. Flows up to 15 m thick occur here, and K/Ar assays of up to 300 Kyr. BP indicate this to be the most recent of the large volcanoes. A U-shaped system of ridges open to the north comprises coalesced pyroclastic cones, the largest of which is Rano Aroi. Rows of craters extend south-southwest from the southern slopes of Maunga Terevaka to Maunga Otu'u, the hard, dark lavas of which are much favored for stone tools, including carved fishhooks. A further line of eruptive centers extends west-southwest from the western flank of Terevaka to Rano Raraku where a wave-cut notch in the southeast rim about 1 km from the present coastline may mark a high sea-level stand, probably of Last Interglacial age.

The moais were carved from the yellowish-brown sideromelane tuff of Rano Raraku. This center originated as a submarine vent which discharged palagonitic tuff and ash of plagioclase, olivine, clinopyroxene and opaque oxides. Basaltic xenoliths and scoriaeous fragments occur in a calcareous cement. Carving projects were occasionally abandoned due to xenoliths, although many of the inclusions were then utilized for stone tools. Most of the lava flows are of hawaiiite composition. A pale aphyric flow from Maunga Hiva hiva near Roiho is an olivine tholeiite. It contains phenocrysts of olivine and is more alkaline than the other lavas of Easter Island. Further to the southwest are lavas which are similar in composition to those of Rano Kau, but which appear to have been emitted from the Terevaka complex; their origin is not clear. In this area lies the 100 m high and 300 m side cone of Puna pau. All the maroke or top-knots which adorned many of the moais and symbolized red hair or headgear were fashioned from this scoriaceous rock, which is blackish when fresh, but weathers to bright red color.

Over 80% of the known caves of Easter Island lie in the Maunga Terevaka lavas. Ana Hotu Matu (Hotu Matua's Caves) lie in a small gully in the Anakena Valley. These spacious chambers are traditionally believed to have sheltered Hotu Matua's party when they arrived at Anakena before the first reed huts were constructed. They are still occasionally slept in by islanders. Nearby stand the moais of the Ahu Anakena, the first of which was re-erected by William Mulloy during the



Small lava cave with entrance steps and retaining walls, near Akahanga.

Norwegian expedition, and the others by Rapanui archaeologist Sergio Rapu.

The coastal strip from just west of Anakena to a point west of Maunga Kuma is a highly restricted zone in the management plan for the Parque Nacional Rapu Nuie (Zentilli, 1977). Motu Tavake (cliff to the Tropical Bird; Lazarus' Cave) lies in this area at Omohi, west of the Hanga-o-Teo plain and at the foot of Vaimataa. It is difficult to reach, its entrance being a narrow squeeze hidden under a projection in a 50 m sea cliff. Sculptures were collected from this cave by Heyerdahl. Nearby is one of several snake carvings known on the island, in part of the world where snakes are unknown.

The entrance to a family cave recorded by Heyerdahl (1958) as "Mayors Cave No. 2" is a horizontal crack which lies 20 m from the top of a 100 m sea cliff near the Ahu Tepeu. Within it he found numerous stone carvings, some of which he speculated may have come from the nearby Ahu to be hidden in the cave during the wars. This cave lies amid the mugearite and benmoreite flows of Rano Aroi.

Various other caves have been reported around the coast facing slopes of Terevaka. Two family caves are reputed to lie above Vaitara Kaiva, another is known in a cliff at Hanga Hemu and another at Hango-o-teo. Many more caves lie in the Maunga Ha'u epa — Maunga Te Puha roa — Maunga Kou'a to the east of Anakena, and at inland locations between here and Rano Raraku. At the latter location a cave in the rock face is reputed to contain three sections, each of which was maintained by a family. Another cave lies at Hotuiti.

Along the coastline between Poike and Rano Kau are a number of caves, some of which contain human remains (Kiernan, 1976). Secret caves have also been reported in this area (Heyerdahl, 1958). One of these is supposed to be at Vinapu and another at Hanga Maihiku. "Santiago's Cave" (Heyerdahl, 1958) is entered via a narrow hole in an overhanging 10 m sea cliff and was found to contain family skeletons and stone sculptures. A residential cave near an ahu in this locality has well constructed stone steps leading into it (Kiernan, 1976).

A more moderate sized cave lies in the sea cliffs west of the airstrip. In the area of mugearite and benmoreite flows nearby lies Ana Kan Tagata (Cannibal's Cave). Various secret family caves are rumored to exist beneath the Hanga Roa Village, not



Sinkhole on the lava flow from Maunga Hiva hiva at Roiho.

all of which are taboo. Heyerdahl examined at least three of the caves in this area. "Mayors Cave No. 1" lies just inland of the route from the village to the leper station, and two or three others, including "Enriques Cave" in the vicinity of the Ahu Paro. In this general area, what appears to have been an old residential cave, now shelters sheep, as indeed do many of Easter Island's caves (Kiernan, 1976). "Wizards Juan's Cave" lies east of the road about 11 km south of the leper station.

Raakau ("Atan's Cave") is named for the moon. Its hidden entrance was shown to Heyerdahl, who collected many of the sculptures which lay on reed mats: "here were curiosities which would make any art dealer tear his hair in excitement . . . fabulous underground treasure chamber." The cave lies north of Puna pau. There are numerous small shelter caves in this general area. Off the western coastline on Motu Tuatara are two burial caves, in one of which a member of the Norwegian party found red hair on a human head.

However, by far the most densely cavernous single area on Easter Island appears to be the olivine lava flows from Maunga Hiva hiva at Roiho (Baker, 1967; Kiernan, 1976). Baker remarks upon "the extraordinary ramification of lava tunnels and tubes which occupy its interior." The surface of this triangular-shaped flow, which covers about 3.5 km², is pockmarked by enclosed depressions about 10 m deep. Some have coalesced to form small pseudo-ovals, the largest of which measures about 200 x 50 m. An entrance through talus beneath the low cliff at the northern end gives access to a spacious cavern 10 m high, but inadequate lighting equipment prevented full exploration of this cave by Kiernan (1976). Caves frequently open off either end of a single sinkhole formed partway along a tunnel. Farther to the west, a lofty passage extends from a 4 m high entrance in another sinkhole. At least 20 cave entrances occur in this vicinity. Some contain old man-made terraces, while in others stone walls have been constructed, presumably to block off passages and alcoves.

VOLCANOKARST BY PIPING

A final series of caves in the Terevaka area is of quite different origin. Surface water is scarce on Easter Island. Springs below sea level were sometimes drawn up directly by the Rapanui, and sometimes intercepted by wells dug in beaches. Precipitation rapidly sinks into the porous volcanic ash, sometimes to reappear as springs where it is brought to the

surface by basalt flows. Pools of water in lava tunnels must also have been important, to judge from the artificial channels and collecting depressions carved in the stone floors of some caves. Some pools near entrances are today fouled by stock. Some surface water is also held in crater lakes. The only surface water is also held in crater lakes.

The only surface stream is that which flows from the crater lake of Rano Aroi. Here piping of volcanic ash has produced a large underground conduit. Partial collapse has produced a 10 m-deep gully, spanned by natural bridges. Bandy (1937) recorded that many of these caves were large enough to admit a man on horseback, but by 1976, much of the system had collapsed to leave the gully spanned in only four places (Kiernan, 1976, 1980). These may be the only penetrable caves on Easter Island which are the product of running water.

OVERVIEW

The lava tunnels of Easter Island are of Tertiary to late Pleistocene age and are formed in fluid pahoehoe lavas of tholeiitic composition as exemplified at Roiho. Detailed speleogenetic studies have not been undertaken, but a few general comments are possible. The lava in which some of the caves are formed is layered. It is difficult to escape the argument of Ollier (1975) that if the lava in the tubes has eroded the layers, as appears to have occurred in some cases here, then the layers must predate the tubes. Thus, in at least some cases here, the hypothesis of Ollier and Brown (1965) seems preferable to formation by the crusting over of surface channels as described by Peterson and Swanson (1974). Evidence exists within those caves observed by the writer for fluvial-type downcutting by prolonged lava mobility after the roof has developed. Flat floors are common and suggest incomplete drainage in some cases, as do convexities in the longitudinal profile of cave floors probably formed due to pressure differentials in the liquid lava rather than degassing. But while some passage infilling by congealed lava has occurred at a late stage, the size of the tunnels and moderate gradient suggests fairly rapid flowage of the fluid rock. Elongate chambers are often linked by low roofed crawls. This form may be related to the formation of flow units (Nicholls, 1936) and/or hydrostatic pressure.

Concentric shelling of the lava parallel to cave roof profiles is commonly exhibited at cave entrances. The tunnels are exposed both by surface collapse due to subaerial erosion and also through truncation of lava flows by marine erosion. Angular blocks on the cave floors reflect secondary breakdown and are most common near entrances. Some tunnels are known to reach 400 m in length. Only small lava stalactites are known to the writer, most little more than botryoidal.

Piping of volcanic ash has resulted from the rapid absorption of rain into the soil, and the overflow of the Rano Aroi crater lake. These piping caves are best developed along the course of the Rano Aroi stream, but a similar process of spring flushing is responsible for micro caves elsewhere, particularly when resistant lava intercepts the passage of underground waters through the pyroclastics.

Similar differential erosion of the pyroclastic and lava rocks by the sea has developed broad, shallow caves around various parts of the coastline. Some shallow caves inland, particularly around Rano Raraku, may be due to marine erosion during

former high sea level stands. Differential erosion by subaerial processes has also been responsible for some shallow rock-shelter caves elsewhere on Easter Island.

The caves of this lonely island have attracted negligible attention from speleologists. Instead, they have provoked some interest from archaeologists seeking to resolve a popular enigma. The caves of Easter Island form a palimpsest upon which is recorded the human experience of man's loneliest and most remote outpost. It is this which provides perhaps the greatest fascination in the netherworld of Hotu Matua's "island full of holes."

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REFERENCES

- Agüera Y Infanzon, F. A. de. 1770. Journal of the principle occurrences during the voyage of the frigate Santa Rosalia...in the year 1770. Hakluyt Soc., 2nd ser., no. 13. Cambridge, 1908.
- Baker, P.E. 1967. Preliminary account of recent geological observations on Easter Island. *Geol. Mag.* 2:116-22.
- Baker, P.E., Buckley, F. and Holland, J.G. 1974. Petrology and geochemistry of Easter Island. *Contrib. to Min. & Petrol.* 44:85-100.
- Bandy, M. C. 1937. Geology and petrology of Easter Island. *Geological Society of America* 48:1589-1610.
- Brown, J.M. 1924. *The riddle of the Pacific*. London.
- Englert, S. 1948. *La Terra de Hotu Matua* (reprinted 1974; Universidad de Chile).
- Fernández, E.N., Jr. 1958. Easter Island exchange systems. *Southwestern J. Anthropol.* 14:136-51.
- Gonzales-Ferran, O., Cordania, U. and Halpern, M. 1974. Potassium-argon ages and Sr 87/Sr 86 ratios of volcanic rocks from Easter Island. Santiago, International Symposium Volcanology Abstracts, p. 28.
- Gossett, R.W. 1938. Easter Island, the land of the statues. *Aust. Geol.*
- Heyerdahl, T. 1958. *Aku Aku*. Penguin Books. (contains location map).
- 1974. Historical Summary. Paddington, N. Y., F. Picker Rapa Nui, pp. 127-31.
- 1976. *The art of Easter Island*. Austria, Allen & Urwin, 349 pp.
- Heyerdahl, T., et al. 1961. Reports of the Norwegian archeological expedition to Easter Island and the east Pacific. Mon. School of Am. Res. & Mus. New Mexico. 24.
- Kiernan, K. 1976. The caves of Easter Island. *Southern Caver* 8(1):7-10.
- 1980. Piping as a pseudokarst process. *Southern Caver* 12(2):35-44.
- Lavachery, H. 1935. La Mission Franco-Belge dans l'Île de Paques. *Bull. Soc. Roy. Geog. d'Anvers* 55:313-61.
- McCall, G. 1981. *Rapanui: Tradition and survival on Easter Island*. Sydney, Allen & Irwin.
- Naval Intelligence Division. 1943. Easter Island. Geographical Handbook series, Pacific islands 2 (eastern Pacific) series B. R. 519B, pp.64-93. Restricted.
- Nichols, R.L. 1936. Flow units in basalt. *Journal of Geology* 44:617-630. ^R
- Ollier, C.D. 1975. Lava caves, lava channels and layered lava. Atti del Seminario Sulle Grotte Laviche, Catania.
- Ollier, C.D. and Brown, M.C. 1965. Lava caves of Victoria. *Bulletin Volcanologique* 28:215-30.
- Peterson, D.W. and Swanson, D.A. 1974. Observed formation of lava tubes during 1970-71 at Kilauea volcano, Hawaii. *Studies in Speleology* 2:209-223. ^R
- Routledge, K.S. 1919. *The mystery of Easter Island: The story of an expedition*. London.
- Thompson, W.J. 1889. Te Pito te Henua, or Easter Island. Washington, Rept. U. S. Nat. Mus. for year ending June 30, 1889.
- Zentilli, B. 1977. Determining national park boundaries. *Parks* 1(4):7-10.