Vulcanospeleological Pseudokarst in Micronesia: an Overview

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In 1984 the Pacific Basin Speleological Survey embarked upon a project to compile a preliminary listing of the known caves in the island nations of the Pacific Basin. Previous American, Australian, French, and British work in Melanesia and portions of Polynesia was a matter of record so Micronesia was selected as the focus of the Pacific Basin Speleological Survey's working area. Pohn Pei, Kosrae, Chuuk, and Yap States of the Federated States of Micronesia; Agrihan, Pagan, Saipan, and Rota Islands in the Commonwealth of Mariana Islands; the Territory of Guam; and the Republic of Belau were visited. Extended expeditions to these areas in 1984, 1986, and 1989 have found a small but significant sampling of volcanic speleological features to be investigated.

Pohn Pei Island

On the island of Pohn Pei rock shelters up to 50 meters wide and deep and 30 meters high have formed in vertical cliffs in the middle elevations of the island. These shelter caves have their origin in the differential weathering of breccia beds intercalated with massive basaltic flows. Small rock shelters, formed either by collapse of basaltic rock outcrops or failure of lava tube segment roofs and containing large amounts of rock art, have been found on the uppermost slopes of the island. Some of these sites are prominent in indigenous people's religious beliefs. In the walls of construction material quarries where Pohn Peians have removed both columnar basalt "logs" and crushed rock for

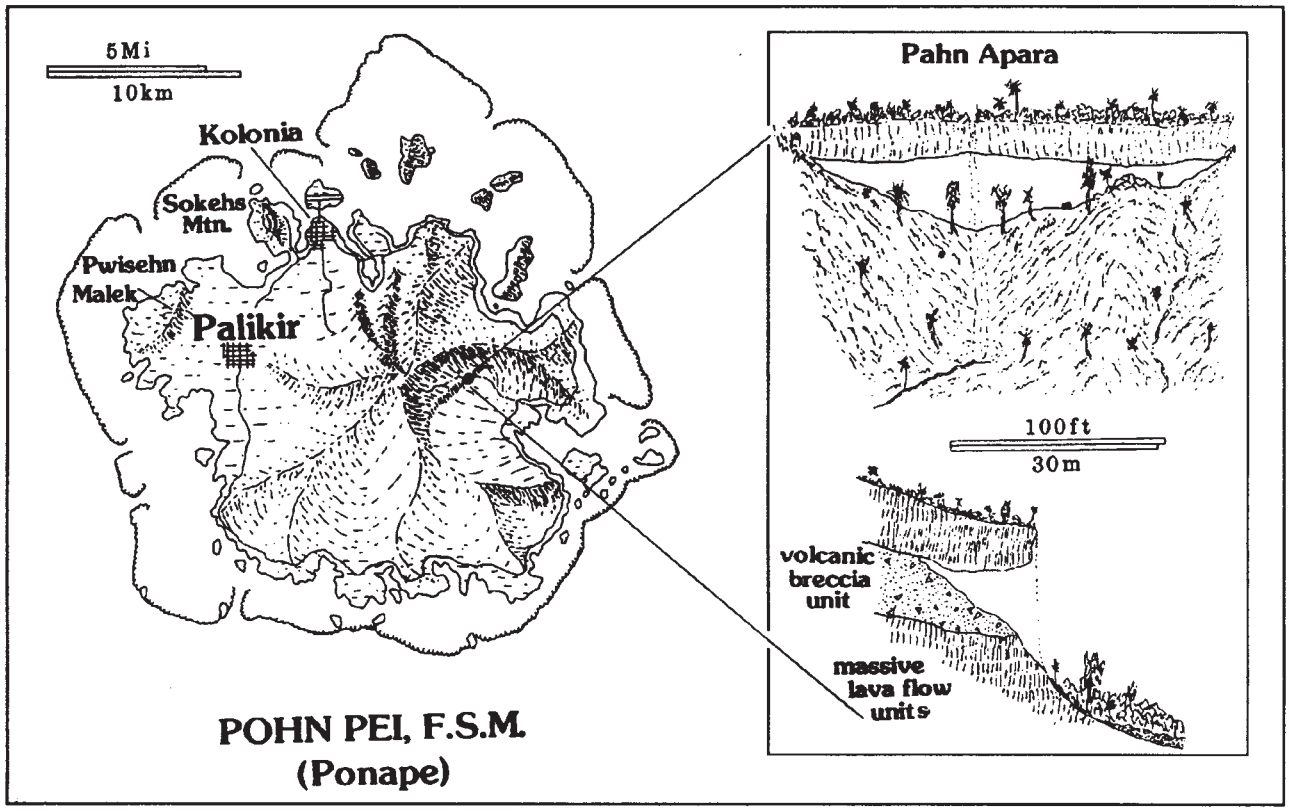

Figure 1—Pan Apra Cave, Pohn Pei. The map of the Island shows the location of Pan Apra Cave (left), a frontal view (upper right), and cross section (lower right) of the cave. Noted both the easily weathered basaltic breccia into which the cave has been eroded and the massive basalt flow unit that forms the cave's roof.

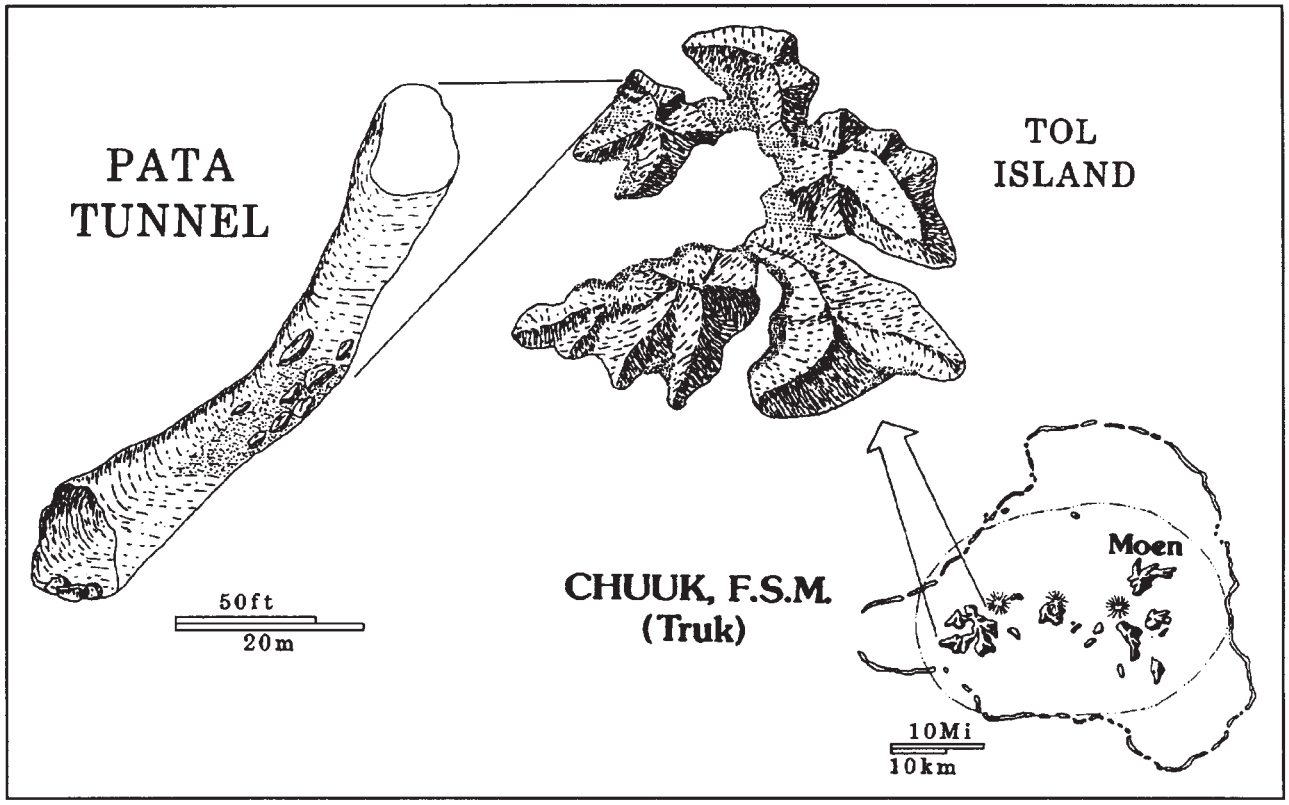

Figure 2—Chuuk (Truk) Island consists of an eroded triple-vented volcano (lower right). On the western island of Tol (top center) is the 61-meter- long Pata Tunnel (left).

over 800 years, many large, lava-filled tubes are exposed. On the lower slopes of the volcanic island are many outcrops of olivine basalt showing kluftkarren development. The origin of these solution forms is poorly understood but may be due to the fact that silicate minerals are unstable in the presence of water high in dissolved carbon dioxide and organic acids common in warm, humid climates.

Kosrae Island

Kosrae State has at least one large lava tube developed in olivine (?) basalt in the middle slopes of the central massif. The cave is approximately ten meters in diameter, is floored with deep deposits of both bird and bat guano, and extends for an unknown distance. Two large colonies of both sacwing(?) bats and cave-dwelling swiftlets occupy the cave.

Chuuk Islands

In the main island grouping of Chuuk State several volcanic pseudokarst features are found. On the Pata Peninsula of Tol Island a 61-meter-long and 10-meter-diameter lava tube in an 8.2-million-year-old olivine basalt lava has been utilized by local inhabitants for many hundreds of years. A local legend attributes the origin of the tube to industrious sea turtles assisting an imprisoned local chief. The Japanese Army also used the cave as a munitions bunker during World War II. On the upper slopes of the island, two 4.6-million-year-old melilite nepheline basalt and nepheline basalt lava flows are surfaced with a meter-high kluftkarren field as a result of the extreme—up to ten meters deep—weathering common to these islands.

Yap Island

There are reports of small sea caves several tens of meters long eroded into the western shores of Yap, Rumung, and Map Islands in Yap State of the Federated States of Micronesia. These have formed in basalt and andesite flows of Cretaceous age. The volcanic rocks were metamorphosed by subduction to a unique suite of garnet-bearing green schists and amphibolites which were subse-

quently exposed by up-thrusting along the Palau-Yap-Mariana trench.

Caroline Islands

The islands of Saipan and Rota in the Commonwealth of the Northern Mariana Islands, the Territory of Guam, and the Republic of Belau (Palau) are largely comprised of elevated Miocene to Recent reefal limestones. These islands, however, also have areas of exposed Paleocene to Eocene volcanic basement rock which has been important to both the local development of karst terranes and as sources of cultural materials for the indigenous peoples of Micronesia. Intercalated basaltic and andesitic lavas and tuff beds in many of these carbonate terrains have channeled ground water which produced solution caves. These beds also allow perching of the local water table, thus producing flashy springs, some of major magnitude. Volcanic agglomerates also are the hosts to many small sea caves in the littoral zones of Guam, Saipan, and Belau. These volcanic rocks have been important sources of tough rock from which the Chamorro, Yapese, Kosraean, Chuukese, Pohn Peian, and Belauan peoples fashioned tools and carved a great variety of megalithic sculptures over the last 3,500 years. Farallon de Pajaros (Uracas), Maug, Asuncion, Agrihan, Pagan, Alamagan, Guguan, Sarigan, and Anatahan Islands in the Northern Mariana Islands are Miocene to Holocene volcanos. All have reported lava tubes and other non-solution caves but little is known of their extent or contents.

Agrihan Island

Agrihan Island is a Quaternary volcano of basaltic and andesitic composition. As recently as 1917 volcanic activity included lava flows down the slopes of the central volcano but little is known of the extent or contents of the resulting lava tubes.

Pagan Island

Pagan Island is the only island in the northern "inner arc" Mariana Islands which has a well known volcanic history. It is a Late Miocene to Holocene composite volcano. Major eruptions in 1872, 1909, 1917, 1923, 1925, 1929-1930, and 1982 have been recorded. While most of the basaltic to andesitic lavas have been erupted as aa flows or pyroclastic deposits, there are moderate-sized areas of pahoehoe flows. In these flows on the west, east, and especially the south flanks of Mount Pagan are concentrations of caves of differing types. Lava tubes up to ten meters in diameter; collapse trenches over 13 meters deep; eruptive fissures, vents, and hornitos deeper than 20 meters; and many 1.5-meter-diameter surface tubes have been reported. Some tubes have been utilized repeatedly with tubebearing younger flows emanating from the older tubes' mouths. Only one series of tubes, however, has been correlated with a documented eruption – that of the February to May 1925 eruption of Mount Pagan. During this eruption, an olivine augite basalt pahoehoe flow descended the west slopes of Mount Pagan at 4:00 A.M. on March 11 and formed a series of lava tubes. Many of these caves are still active fumaroles, emitting hot air and steam. The extent and composition of secondary deposits in these and the other known older tubes are unknown;

Figure 3 – On Pagan Island are many lava tubes formed during the 1929 eruption. This tube is approximately a meter high and three meters wide. (U.S. Geological Survey photo)

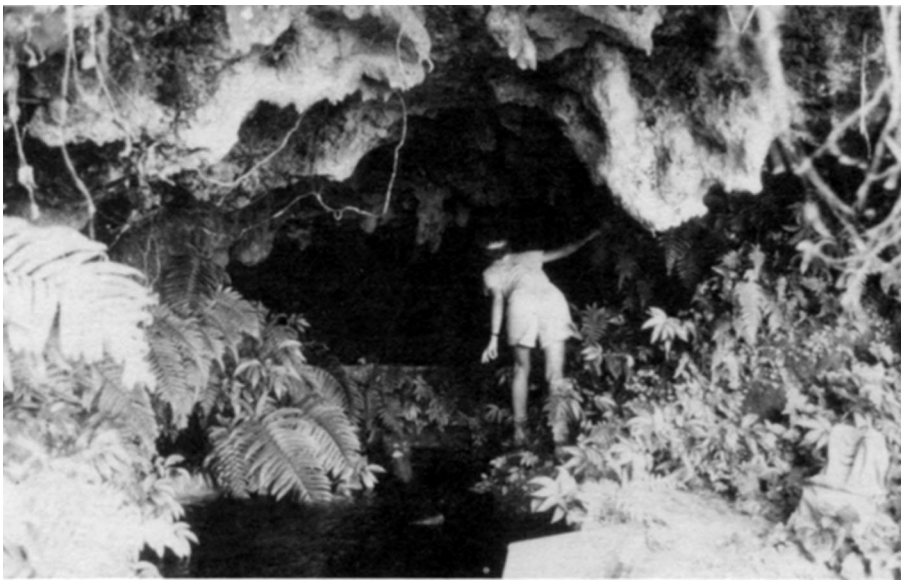

Figure 4—Charmaine Legge looks into the outlet of Waterfall Cave on the southeast side of Luta (Rota) Island. This large karst spring is perched on a thin bed of andesitic volcanic rock.

however, inferences of sulfur and carbonate deposits are found in the literature.

Inland from many of the steep, rocky headlands are areas of fissure caves up to ten meters deep formed by separation of basalt blocks from the headlands and resulting slow seaward creep. Along the east and northwest coasts of Pagan are deep sea caves formed by littoral excavation of loose clinker. The caves have roofs and floors of massive basalt flow units.

The constant volcanic activity, civilian and military construction during the 1941-1945 Japanese occupation, and 1950s U.S. Marine and Navy war games activities have all but erased evidence of Pagan Island's earliest inhabitants, thus we know nothing of their utilization of the island's caves. The Spanish and German occupiers of the island left little record of their activities but we do know that they mined sulfur from various sites in the inner crater of Mount Pagan. The Japanese mined the same(?) deposit as well as deposits discovered near the summit of the south cone of South Volcano during 1917 and 1934. The amount of sulfur obtained was small, the labor considerable, and both operations were abandoned. During the 1982 eruption of Mount Pagan, inhabitants of Lagona Village sought shelter in lava tubes for several days until evacuated by ship. Only incidental observations of spelean biology have been made. Reports of large populations of cave-dwelling insectivorous and fruit-eating(?) bats have been made as well as of forest-dwelling flying foxes.

Rota Island

The island of Rota, in the Marianas, derives its water supply from a large karst spring perched on the island's andesitic basalt pile. A small cave in agglomerate has developed at the island's Sabana District summit. Other deposits of fine-grained andesite and andesitic basalt exposed on the southeast coast were utilized as sources of stone for tools.

Saipan Island

On the island of Saipan in the Sabana Dan Dan area are small soil pipe caves which have developed in tuffaceous siltstones and sandstones of the Eocene Hagman Formation. In the Eocene andesitic volcanic rocks of the Hagman Formation exposed on the Hagman Peninsula are several small caves at sea level. Deep fissure caves in up to ten-meter-square creeping blocks of tuffaceous sandstone and conglomerate are also present. Other small sea and fissure caves in the Hagman sandstones and conglomerates are located along the sea level areas of Punta I Naftan. Andesite and dacite from the Eocene and Eocene(?)

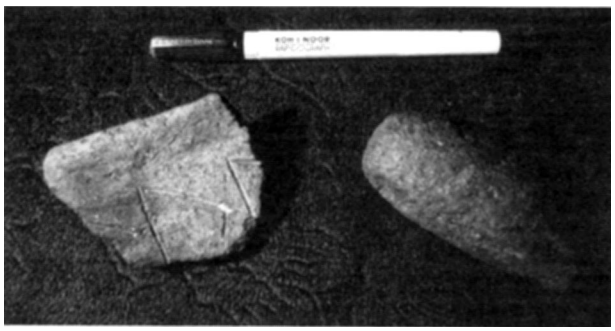

Figure 5—The original Chamorros inhabitants of Saipan Island utilized both the basalt bed rock to fashion tools (right) and the weathered basalt clay-rich soils to construct pottery (left). These pieces from Cave of the Sinking Waters are approximately 1,000 years old.

Densinyama, Hagman, and Sankakuyama Formations were locally quarried for tool making.

Guam Island

On the island of Guam are several areas of badland topography including small soil pipe caves developed in tuffaceous shale of the Eocene to Oligocene Alutom Formation. Along the southwest coast of the island are small sea level caves developed in the basalt and basalt breccia of the lower Miocene Umatac Formation.

Palau Islands

In the northern volcanic islands of the Republic of Belau short sea level caves have developed in Eocene to Oligocene basaltic andesite, andesite, and dacite flows and breccia of the Babeldaop, Aimeliik, and Ngeremlengui Formations. Large slabs of andesite also furnished material for the extensive megalithic sculpture tradition and for tools used in the islands.

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