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'Ōhi'a Project Insert - Geology

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Reawakened Volcanic Fires of Honolulu

The Honolulu Volcanic Series Includes Forty Eruptive Sites

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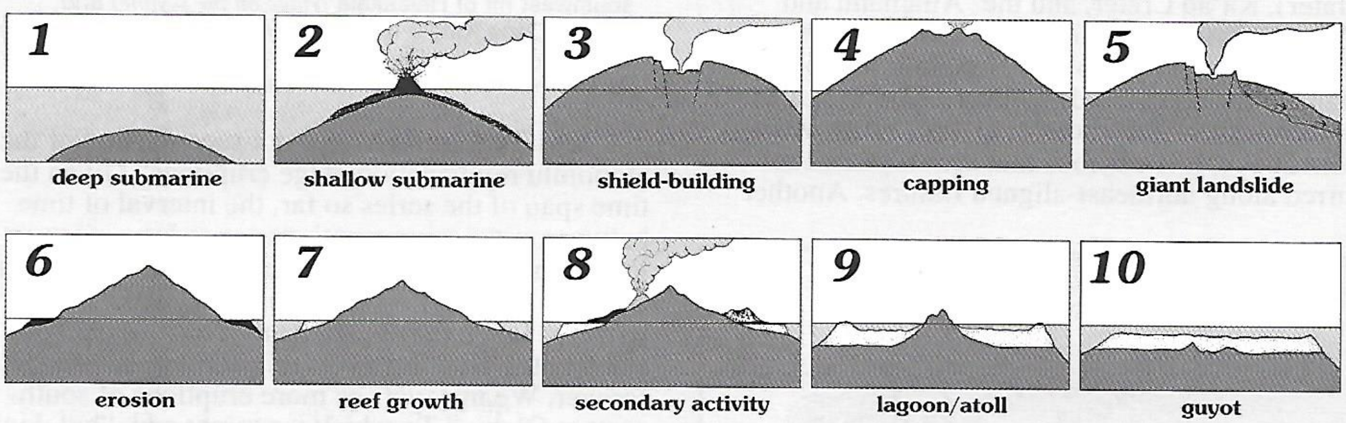
THE WORLD'S IMAGE OF HAWAI'I includes white sands and palm trees, with the famous profile of Diamond Head in the background. This world-renown icon is also a fine example of what geologists called rejuvenation-stage volcanic activity. It is part of a typical pattern of volcanic activity in the geological history of a typical Hawaiian island.

All of the main Hawaiian islands were and are being formed by volcanic activity, sustained by a "hotspot" generated when a rising plume of hot material from the earth's mantle meets the lithosphere (or earth's crust). The magma breaks and melts its way upward, usually following zones of weakness in the crust at fractures and faults, until it emerges through the crust as lava and builds a volcano. This is just the very beginning of a long and varied *life cycle* of a Hawaiian volcanic island.



Life Cycle of a Hawaiian Volcanic Island. *Modified from the 'Ōhi'a Project.* MGF, 1989.

In the typical sequence of events, a Hawaiian volcano begins erupting at the bottom of the central Pacific Ocean, building a submarine shield (stage 1) which eventually emerges above sea level (stage 2) and builds a gently sloped shield volcano composed of many eruptive flows (stage 3), with eruptions every few years, and period of high volume activity (as the 14½ year-long Kīlauea activity of today). As the shield matures, activity declines to one per several centuries or even millennia, and the composition and nature of the erupted lava changes, usually forming a cap of cinder and alkalic basalts (stage 4). With fewer eruptions, the forces of erosion dominate (stage 5 & 6)—eating away at the original shield, giving us the spectacular valleys and ridges of an island such as Moloka'i, or the great *pali* of the Ko'olau mountains of O'ahu.

Why should volcanic activity decline on an island?

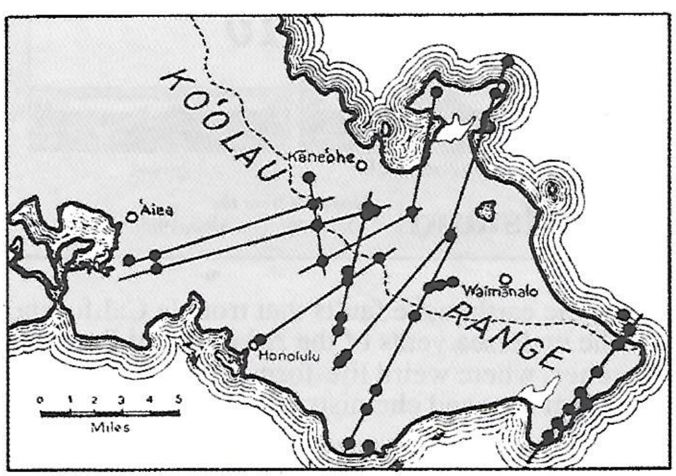
THE ANSWER LIES IN THE MOVEMENT of the crust of the Pacific Ocean basin. Today we know that the crust of the earth is by no means static. Huge plates of crust move about slowly but inexorably, colliding, sliding against and under each other, all driven by huge convective movements of the molten rock in the earth's mantle. At the boundaries of these plates lie some of the most geologically active zones, the earthquake faults that trouble California, and the undersea vents of the Atlantic and Pacific rift zones, where weird life-forms derive their energy from heat and chemistry rather than the sun.

The Pacific plate is one of the largest, and moves westward and northward. The central Pacific plume and hotspot remains relatively stationary despite the movement of the Pacific plate, so that as a volcano builds, it eventually is carried away from the plume and therefore from the main source of rising magma. Ironically, what are called *secondary* or *regeneration-stage* eruptions (stage 8) are actually the last declining events in the volcanic sequence. They seem like a rejuvenation because the initial stage of main shield-building has long been over, and when the rejuvenation-stage eruptions occur, they break through into an eroded landscape that had typically not seen such activity for perhaps half a million years or more. This is why they are also called "post-erosional" volcanics.

As infrequent as they might be, the rejuvenation stage eruptions tend to be of great power, perhaps because of a higher content of magmatic gases present in what is presumably the edge of the magmatic plume. The lava tends toward alkalic basalts with abundant olivine, and other rock types not previously erupted, such as nephelinites and basanites. The eruptions build large cinder cones, and when encountering groundwater or erupting at the coast or in shallow ocean water, can be explosive and charged with superheated steam.

One of the most prolific of the post-erosional, rejuvenation-stage series is called the Honolulu Volcanic Series.

THE VENTS OF THE HONOLULU SERIES include the landmarks of Lē‘ahi (Diamond Head), Pūowaina (Punchbowl), Hanauma, Kohelepelepe (Koko Crater), Ka‘au Crater, and the ‘Āliamanu and ‘Āliapa‘akai (Salt Lake) crater cluster. Near and offshore expressions of the Honolulu series include Mānana (Rabbit Island), Ulupa‘u, and Moku Manu on the northeastern shore of O‘ahu. When viewed from above, it is obvious that the eruptions occurred along northeast-aligned fissures. Another



Map of southeastern O‘ahu showing Honolulu Volcanic Series vents and dominant rift trends. Source: *Volcanoes in the Sea* (from Stearns, 1934).

familiar set along a fissure is ‘Ualaka‘a (Round Top), Pu‘u Kākea (Sugar Loaf), and Pu‘u ‘Ōhi‘a (Tantalus), ash from which blanket the Honolulu plain twelve feet thick from Punchbowl to Punahou Streets.

Maui, Moloka‘i, O‘ahu, Kaua‘i, and Ni‘ihau show rejuvenation-stage eruptions. Perhaps the most famous of the Maui rejuvenation series includes offshore Molokini islet and the historic flows that formed La Perouse Bay at ‘Āhihi Kīna‘u at about 1790. The Moloka‘i landmark of Kalaupapa peninsula is perhaps that island's most prominent rejuvenation-stage feature. Like O‘ahu's Kaimukī eruption, it formed a small shield volcano, rather than a cinder cone. O‘ahu's Honolulu series range in age from just over a million years to just over 30,000 years old. On Kaua‘i, rejuvenation stage volcanoes are particularly widespread, comprising about 40 scattered vents in what is called the Kōloa series. The youngest of these are about half a million years old, but a submarine eruption is thought to have happened south of Kaua‘i in 1956!

Photo: A. Yoshimoto

The most recent eruption on Maui occurred on the lower southwest rift of Haleakalā *(ridge on the skyline)* and formed Cape Kīna‘u *(center, right)*. The dark flows *(center, below the cones on the rift)* mark the lava paths from two vents which created this peninsula.

Could it be that we have not seen the end of the Honolulu rejuvenation-stage eruptions? Given the time span of the series so far, the interval of time between successive eruptions are as long, or even longer than the length of time from the most recent eruption to today. As Gordon MacDonald *et al.* wrote in *Volcanoes in the Sea*: "Thus we cannot say that the Honolulu volcanic activity has ended forever. We may yet see more eruptions of southeastern O‘ahu." To which we might add, "but don't hold your breath waiting!"

For a recent overview of Hawaiian Island volcanology, please see George P.L. Walker's article: *Geology and Volcanology of the Hawaiian Islands*, in ***Pacific Science***, Volume 44, pages 315-347. The article was recently reprinted in ***A Natural History of the Hawaiian Islands: Selected Readings II***, edited by E. Alison Kay, University of Hawai‘i Press, Honolulu.