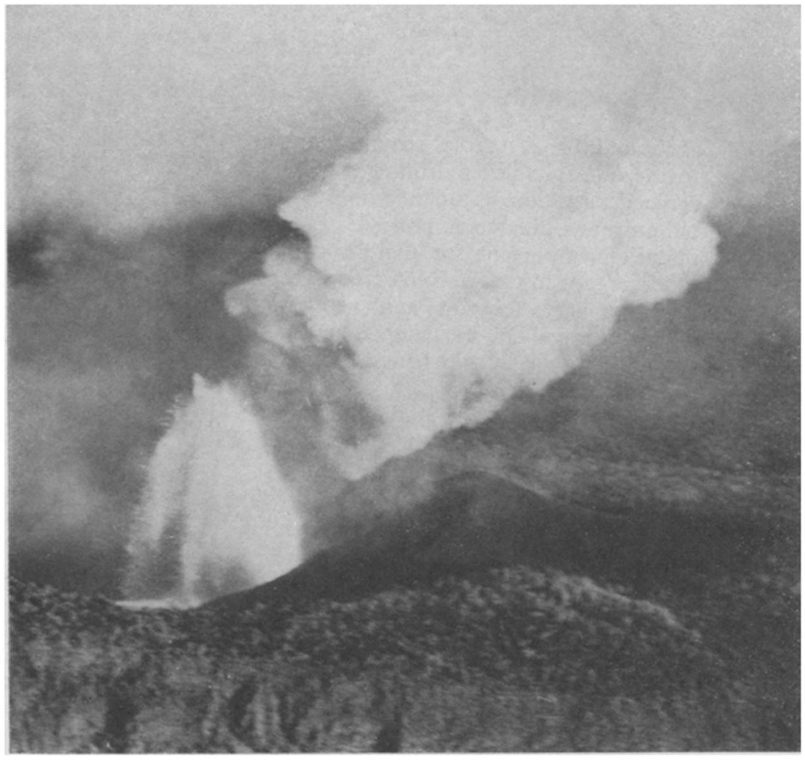
Life studies flow from live volcanoes

Radically changing environments and climatic conditions produced by volcanoes create fruitful ecological laboratories

by Richard H. Gilluly



Photos: Smathers, NPS

New life systems follow Kilauea's devastating eruptions.

Man is changing his physical, chemical and biological environment at an accelerating and often alarming pace; natural forces generally move far more slowly. An exception is when these forces produce a cataclysmic event such as the eruption of a volcano. Then the physical environment is altered radically in a matter of hours, days or weeks. As soon as the lava begins to cool, new life systems follow into the devastation area, some slowly, some quickly.

So ecologists have begun to realize that a new or frequently erupting volcano provides a rich opportunity to study the interaction of life with its environment. The volcano and its surroundings become a kind of ecological laboratory.

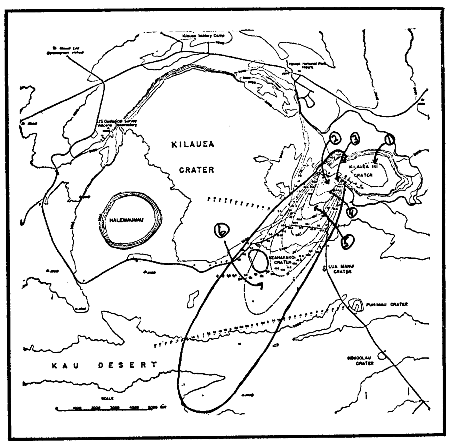
Because of the newness of the science of ecology, the work on volcanoes has only just begun. But, says Dr. F. Raymond Fosberg, Smithsonian Institution ecologist, it promises to be highly fruitful.

One site that is particularly interesting is Kilauea, on the island of Hawaii. One of the world's most active volcanoes, it not only provides new physical environments by frequently disgorging lava and cinders, but also presents a variety of climatic conditions because of the island's position in the path of trade winds. Rainfall on its slopes can vary from 20 inches a year to several hundred. Scientists can observe life forms as these adapt to the new physical and chemical environments of lava; they also can observe the many different conditions for life that are created as a result of differing climatic conditions.

Hawaiian volcanoes are generally of the shield type; lava is fluid enough so that it erupts in a fountain or wells quietly from the surface, then flows in ever-widening pools that form shield-like formations as they harden. There are few of the violent explosions of the sort that built steep, conical mountains such as Fujiyama in Japan or startled the world in 1883 when Krakatoa exploded. The lava flow from Kilauea is gentler, and its slopes and those of nearby Mauna Loa are also gentle. The great spreading of the lava flows that formed the island of Hawaii have made it one of the world's largest monolithic land masses, and the lush greenness of much of the island attests to life's ability to establish itself in such an environment.

However, the process of forming of a fully mature ecosystem in a volcanic devastation area takes at least 175 years, and probably longer. Historical records of eruptions for the island of Hawaii go back only this far, and the devastation areas from the oldest ones have not yet produced mature systems. The formation of soil from lava—a key factor in the establishment of life—involves wind, rain and microbial action. It is a process which requires life or the remains of life, but it also paves the way for new life forms. "The formation of soil is both a cause and effect," Dr. Fosberg says.

Lava welling or fountaining from a volcano ends in a number of different final forms, and these forms are important variables in establishing the pace of soil formation. Pahoehoe lava, which wells up from the ground and hardens into ropy forms which resemble cold molasses, is a solid and



Devastation area and six habitats.

nonporous material which presents a formidable obstacle to the establishment of life and to soil building. But Aa lava, because of the way gaseous materials leave it as it hardens, is more granular and thus more amenable to conversion to soil. Pumiceous cinders, materials thrown into the air near the end of an eruption and blown downwind, are light and porous and also a good source of soil because of their water- and air-holding capacity and the exposure of more of their surface to weathering and microbial action.

Of great importance to the success of life at Kilauea is the ohia tree, a hardwood that is almost ubiquitous in the Hawaiian Islands. The ohia is often able to survive partial inundation in lava or cinders, and new ohia trees begin growing in certain parts of devastation areas, apparently from windborne seeds, almost as soon as lava cools. Whether the new trees are the same as the old, or are special strains adapted to the inhospitable environment of volcanic devastation, is unknown. But the old and new ohia trees provide organic materials important for the growth of other organisms. "The ohia tree is ecologically very tolerant and very important," says Dr. Fosberg. The trees will grow only in the heavier rainfall areas.

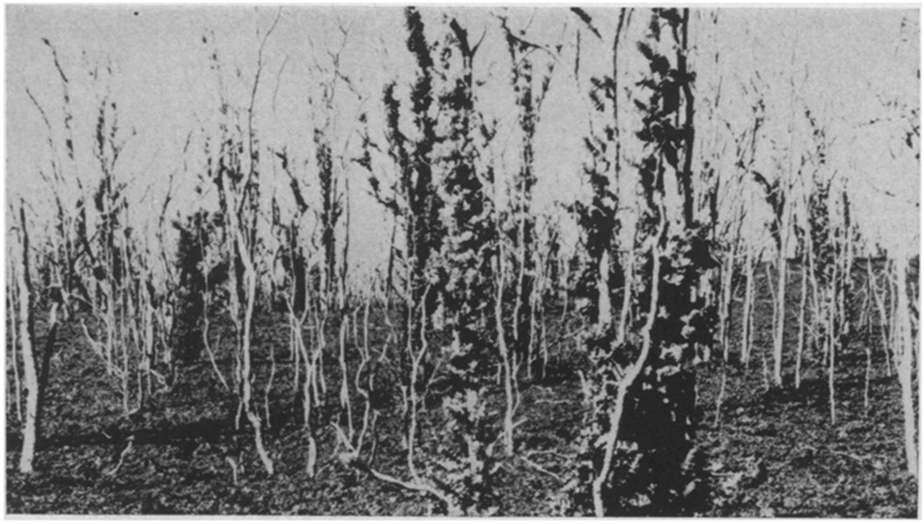
The most intensely studied area of the Kilauea complex is the one created in a 1959 eruption near Kilauea Iki crater. The older crater was partially filled with pahoehoe lava, and various kinds of environments were created downwind by materials from the eruption. Garrett Smathers, a National Park Service research biologist, has delineated these areas according to the influence of types of lava, and he and other scientists have observed the establishment of life forms in them. The greatest amount of growth occurred in the area where ohia trees survived the eruption and where pumice was in relatively small chunks. Besides the ohia, several other species of trees and herbs were well-established by 1968. Ferns, mosses, lichens and algae were also found in this area in 1968, or earlier.

Some organisms establish themselves in a devastation area almost immediately, even in a habitat such as the Kilauea Iki crater which is mainly pahoehoe lava. It had been thought that lichens—symbiotic colonies of bacteria and fungi—might be the first invaders, but a fern and an alga were found in the crater in 1960, The first lichen did not arrive there until 1961, Smathers reports.

The action of microorganisms in soil-building is not yet fully understood. Ecologists assume that carbonic or other acids excreted by microorganisms break down the hard silicates of lava. But with work at Kilauea Iki by Dr. M. L. Fields of the University of Missouri, there are now some clear indications of the kinds of environments that favor microbial growth.

The silicates in very new lava apparently have toxic properties which prevent growth of microorganisms. But detoxification takes place over a relatively brief period, and algae were established by 1968 in all the Kilauea Iki habitats delineated by Smathers.

Another important variable is the ratio of calcium, magnesium and potassium. Although lava as it comes from the earth contains all of the nutrients, except nitrogen, required for plant growth, ratios of these materials vary, and a high ratio of potassium to magnesium in the area designated as edaphic desert may be one of the reasons for lower plant growth there, says Dr. Fields. But he adds that lower rainfall and smaller amounts of organic material may also be important factors.



Hawaii's ohia tree provides organic materials after surviving pumice burial.

There is also a correlation between amounts of organic material and microbial growth, and areas with the greatest growth of higher forms also had the greatest microbial growth, each contributing to the other.

Dr. Fields found protozoa ciliates in all of the habitats except in the pahoehoe lava in the Kilauea Iki crater and in the nearby pumice cone. Filamentous fungi were found in all of the environments, although in far larger numbers where there was more organic material available and the pumiceous cinders predominated.

Actinomycetes, which are a form of microflora between fungi and bacteria, were found in all habitats, although they were fewest in a desert area and most numerous in the habitat where there were dead trees and volcanic spatter: larger chunks of material nearer the crater. Thermophiles—algae, bacteria or fungi which prefer a heated habitat — were predictably found in greatest numbers in the crater where there are steam vents and other sources of heat from the still-cooling lava. There were few thermophiles in the other habitats, but mesophiles—microorganisms favoring a more temperate temperature range—were found in both the unheated and heated habitats. Dr. Fields assumes that either there are temperature variations in the heated areas or that the mesophiles are able to endure the higher temperatures.

The latest eruption of Kilauea began in May 1969 and is still continuing. A June lava flow went from its source at the 3,000-foot level to the sea, and Smathers says the new flow will provide a rich field because it encompasses so many climatological zones.

Lava from steam vent on crater floor.

Although there are a number of volcanoes in the Circle of Fire around the Pacific, Kilauea is getting the most intensive ecological attention. There are similar ecological laboratories elsewhere in the world. Surtsey, a volcanic island off the southeast coast of Iceland, which began to be created when it emerged from the sea spectacularly shrouded in steam and fire in 1963, is still fascinating biologists from all over the world because it is a wholly new habitat. To prevent contamination, the Government of Iceland has sharply restricted travel to the island except by scientists. Studies show that algae moved into Surtsey from the sea almost immediately after its formation, and small visible plants are now growing in sandy volcanic ash called tephra which formed Surtsey's beaches.

Much new plant growth was discovered in the summer of 1967, seeds apparently having been borne to the island by the sea, wind or birds. The first flowering plant was observed then, as well as the first grasses. Other macro-

Fields: A search for microbial growth.

Spatter lava converts more easily.

scopic plants included mosses.

Animal life came to Surtsey early, too. Seagulls were seen on the island in its first month of existence, although they did not stay. But soon the seagulls, and other birds, moved in permanently, along with seals, flies and butterflies. Since then, a large variety of animals have colonized both terrestrial and underwater portions of the island. An early arrival was the squid which were washed up on the beaches at Surtsey.

The ecological study of volcanoes began at Kilauea in 1959 and at Surtsey even later. So far, successions of organisms in various parts of devastation areas have been partly identified, and the areas hospitable to life chemically, physically and biologically analyzed. But the developing relationships between life forms have only begun to be studied. Volcanoes may eventually yield knowledge of primordial processes which establish the interrelationships between life forms. □