The geology of the kilauea volcano (hawaii)

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IntroductionVolcanoes are mountains formed by the accumulation of materials erupted through one or more openings in the Earth??™s surface.

Most volcanoes have steep sides, but some can be gently sloping mountains or even flat tablelands, plateaus, or plains. The volcanoes above sea level are the best known, such as Mount Kilauea, but the majority of the world?? ™s volcanoes lie beneath the ocean, which are formed along the global oceanic ridge systems along the ocean floor. According to the Smithsonian Institution, more than 1, 500 volcanoes above sea level have been active during the past 10, 000 years and about a third of them erupting one or more times during written history. (MSN Encarta, 2009) Tilling (1999) wrote that ??? One of the most spectacular, awesomely beautiful, and at times destructive displays of natural energy is an erupting volcano, belching fume and ash thousands of meters into the atmosphere and pouring out red-hot molten lava in fountains and streams.

??? Mount Kilauea is one of the world??™s largest active volcanoes, yet its effusive eruptions generally pose little threat to residents of Hawaii (Cook, 1982). It is located in the Hawaiian Islands of the United States of America, precisely 19. 421?° N and 155. 287?° W (Global Volcanism Program, 2009). Its low, broad shape resembles a warrior`s shield (NASA, 2009).

Since January 3, 1983, Mount Kilauea has been continually erupting until this very day. This current eruption is also known as the Pu? u ? O? o – Kupaianaha eruption (Fischer, 2009). Kilauea is the youngest major shield volcano now protruding above sea level, and much of its mass is under water. The shield dimensions are 180 km by 75 km, elevated at 1, 250 m, or

6, 750 m above seafloor. The caldera (a cauldron-like volcanic feature usually formed by the collapse of land following a volcanic eruption) dimensions of the caldera are 3. 5 by 5 km, and the depth has exceeded 270 m.

(Holcomb, 1990)Hawaiian HistoryThe Hawaiian Islands (which are entirely of volcanic origin) formed in the middle of the Pacific Ocean more than 3, 200 km from the nearest plate boundary (USGS, 2009). Hawaii, known as the Big Island because its 4, 030 square miles of area is greater than all seven other Hawaiian islands combined, is the world??™s largest volcanic island after Iceland (Cook, 1982). Each Hawaiian island is made up of at least one primary volcano, although many islands are combinations of more than one. The Big Island is composed of 5 major volcanoes including Kilauea, Mauna Loa, Mauna Kea, Hualalai and Kohala. (Rubin, 2005)Volcano Formation ??“ Plate Tectonics and HotspotsVolcanoes are not randomly distributed over the Earths surface. Scientists have developed a now generally accepted theory called plate tectonics that explains the locations of volcanoes and their relationship to other large-scale geologic features.

(Brantley, 1994) According to plate tectonics, the Earth??™s surface is broken into a number of shifting plates about 80 km thick, which move in slow motion. The plates change size and position over time, moving at speeds of between 1 cm and 10 cm every year – about the speed at which fingernails grow. (BBC NEWS, 2000)Yet, there is a small percentage of the world??™s active volcanoes are not associated with plate boundaries. Many of these intra-plate (within the plate) volcanoes, such as Mount Kilauea, form roughly linear chains in the interior of some oceanic plates. The Hawaiian

Islands is an intra-plate volcanic chain, developed by the northwest-moving Pacific Plate passing over a fixed hot spot that starts the magma-generation and volcano-formation process.

The borderline of the Pacific Ocean Basin containing the boundaries of several plates are dotted by many active volcanoes that form the Ring of Fire. (Tilling, 1985) The Ring of Fire is an area where a large number of earthquakes and volcanic eruptions occur in the Pacific Ocean Basin. More than half of the world??™s active volcanoes above sea level are part of this ring. (BBC NEWS, 2000) (See Appendix A)The Hawaiian Island-Emperor Seamounts chain extends about 6000 km from the Big Island of Hawaii to the Aleutian trench off Alaska. The Hawaiian Islands themselves are a very small part of the chain and are the youngest islands in the mostly submarine mountain chain composed of over 80 volcanoes.

The amount of lava erupted to form the Hawaiian-Emperor chain was calculated to be at least 750, 000 cubic kilometres. (USGS, 1999) Canadian geophysicist J. Tuzo Wilson proposed the hotspot theory in 1963. Wilson hypothesized that the linear shape of the Hawaiian Island-Emperor Seamounts chain resulted from the Pacific Plate moving over a deep, immobile hotspot in the mantle.

Heat from this hotspot produced a source of magma by partly melting the overriding Pacific Plate. Continuing plate movement eventually carries the island beyond the hotspot, cutting off the magma source, and ceasing volcanism. As one island volcano becomes extinct, another develops over

the hotspot, and the cycle repeats itself. This process has left a chain of volcanic islands across the Pacific Ocean floor.

(USGS, 2009)Volcano TypeMount Kilauea is a shield volcano, which is a broad, shield-shaped volcano many tens of kilometres in circumference and more than 2 km high built by successive flows of fluid basaltic lava from a central vent (Jordan & Grotzinger, 2009). Magma rises through the upper mantle, which forms a magma chamber in the Earth??™s Crust. Lava then erupts through central or side vents which accumulate on the surface to form a volcano with gently sloping cone of flat, domical shape. Shield volcanoes are built almost entirely of fluid lava flows. They are built up slowly by the accretion of thousands of flows of highly fluid basaltic lava that spread widely over great distances, and then cool as thin, dipping sheets. Lavas also commonly erupt from vents along fractures (rift zones) that develop on the flanks of the cone.

(Tilling, 1985) Their heights are typically about 1/20th of their widths. Cross-sections through shield volcanoes reveal numerous thin flow units of pahoehoe basalt, typically less than 1 meter thick. (SDSU, 2009)Lava FlowsLava flows consist of magma flowing along the Earth??™s surface. The most common magma in Hawaii consists of basaltic lavas, which have a mafic composition (high in iron, magnesium, and calcium) and has the lowest silica content of the three lava types (Jordan & Grotzinger, 2009). Basaltic lava, which flow from shield volcanoes such as Mount Kilauea, is generally placed in two different categories. The two different types of basaltic lava flows are called pahoehoe and a??™a, which are Hawaiian terms used to describe the texture of the lava.

Pahoehoe lava is described as smooth, continuous, and rope like. Its high temperature and high dissolved gas content keep it fluid and runny. As it flows, it twists into rope-like shapes.

The second, a??™a lava, is described as blocky and rough fragments which are sharp and jagged. A??™a lava often occurs in large lava flows that can range up to 10 metres thick. A??™a lava also has a lower temperature and a thicker consistency than pahoehoe lava and moves more slowly. (MSN Encarta, 2009) Since the surface of a??™a lava is loose and broken, many tourists say it makes hiking difficult and slow. A??™a lava typically erupts at temperatures between 1000 to 1100 degrees Celsius. GasesAll eruptions, explosive or non-explosive, are accompanied by the release of gas, primarily in the form of steam. Most volcanic gases consist of water, carbon dioxide, and sulfur dioxide.

The sudden escape of high-pressure volcanic gas from magma is the driving force for eruptions. Gases come from the magma itself or from hot magma coming in contact with water in the ground. Volcanic plumes can appear dark because of a mixture between the gases and pyroclastic materials. Carbon dioxide released from volcanoes has a continuing influence on the Earth??™s climate. The volcanic gases create a greenhouse effect which heats the atmosphere by carbon dioxide.

The greenhouse effect has helped keep the planet warm enough to suffice life for hundreds of millions of years. Without carbon dioxide from volcanoes, the oceans would have frozen over. (MSN Encarta, 2009)Eruptive HistoryThe

arrival of Christian missionaries in 1823 started the official written records of Mount Kilauea`s activity.

The following century saw nearly continuous eruptions in the caldera. The continuous eruptions ended in 1924 with deep subsidence and an explosive eruption at Halemaumau (Kilauea`s pit crater). Eruptions would occur occasionally in Halemaumau through 1934, and after following a hiatus, eruptions resumed in 1952. Eruptions returned to the East Rift Zone in 1955 and were frequent on the summit (the highest point) and flank (the side) until 1968. In 1969, summit eruptions became less frequent and that activity so far built lava shields, extensive flow fields and pyroclastic deposits. (Holcomb, 1990) During the 200-year long historic record of Kilauea Volcano, the Pu? u ? O? o eruption (which is currently in action) has the distinction of being the longest-lived rift zone eruption. It is also the most voluminous, flowing over 2.

7 cubic kilometres of lava, and also one of the most compositionally variable in the Kilauea historic record. (Rubin, 2008)Eruptions and Eruption CharacteristicsMount Kilauea has mostly effusive lava flow eruptions. Minor pyroclastic eruptions have been found to produce at the crater or along the flanks of cinder cones. Eruptions at Kilauea often occur in the Kilauea caldera and also along the East Rift Zone. Magma supplied to the Kilauea summit is distributed through eruptions in the caldera and along the upper and Middle East Rift Zones that extend more than 20 km from the summit (Baxter et al., 2005). Fischer (2009) found that in the course of the eruption starting on January 1983, lava flows have destroyed Waha? ula heiau, a famous 700 year-old Hawaiian temple, overrun many houses, permanently blocked out

several highways, and even destroyed the old National Park Visitor Center. Hawaiian Volcano ObservatoryThomas A.

Jaggar, founder the Hawaiian Volcano Observatory, first visited Hawaii 100 years ago during a decade long period of exploration. There he witnessed first-hand the destructive power of volcanic processes. Following the natural disaster of an earthquake in 1908 near Mount Etna in Italy that killed 125, 000 people, Jaggar declared that ??? something must be done??? to support systematic studies of seismic and volcanic study.

In 1909, he travelled to Mount Kilauea and determined that it was to be the first home of the American volcano observatory. His vision was to ??? protect life and property on the basis of sound scientific achievement???. In 2012, the Hawaiian Volcano Observatory will celebrate its centennial anniversary. (USGS, 2009)HazardsEruptions pose direct and indirect hazards to people and property both on the ground and in the air. Direct hazards are lava flows, pyroclastic flows, falling ash, and debris flows.

Indirect hazards are usually non-volcanic effects that follow or accompany eruptions. Some indirect hazards would include earthquakes and tsunamis, a lot of which occur around the Ring of Fire. Tsunamis are large seismic sea waves that are generated by a sudden movement of the seafloor. The movement can be caused by a large earthquake or by the collapse of an island volcano. Tsunamis can devastate low-lying areas and can become deadly if people living in these areas are not evacuated.

(MSN Encarta, 2009)Hawaiian volcanoes usually pose the most risk to property and unwary visitors. Occasionally, eruptions are dangerously

explosive, such as Kilauea??™s eruptions of 1924 and 1970, which had generated large volumes of ash. (MBARI, 2009) The Hawaiian Volcano Observatory updates its website daily with status reports, updates, and information releases of all Hawaiian Volcanoes. Recently, on May 25, 2009, the Hawaiian Volcano Observatory issued a bulletin warning of the hazards presented by Mount Kilauea??™s lava delta, including the possibility of hot rock falls and collapses that can occur with little to no warning. Also, the steam plumes that rise from lava entering the ocean contain fine lava fragments and acid droplets which can be harmful to human health. (