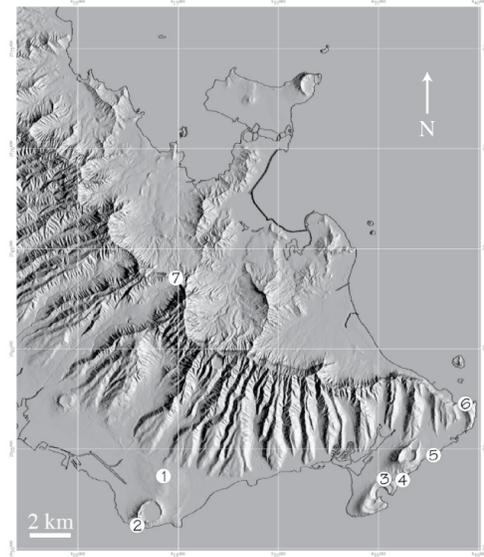


Diamond Head Tuff Ring Field Study

Discussion Points and Answers to Student Worksheet Questions

The southeast portion of the island of Oahu is shown in the shaded relief map, in shades of gray (image at right). Notice how this map accentuates landforms such as river valleys, volcanic vents of the rejuvenation stage of Ko'olau Volcano, and the ridgeline that forms Oahu's pali. We will visit the southern slope of Diamond Head tuff ring, a prominent topographic feature near the circle labeled "2". The color satellite image (below) focuses on Diamond Head and the immediate surroundings. Because this is a true color image of the ground surface, it is possible to make out manmade structures such as buildings and roads, in addition to natural features such as the Diamond Head tuff ring, beaches, and coral reefs.

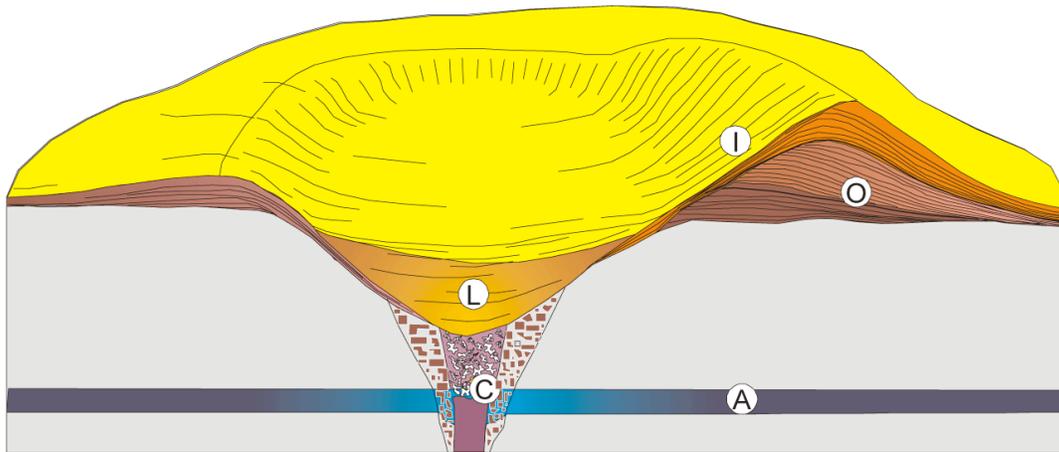


Diamond Head Tuff Ring Field Study

Introduction

Tuff rings are shallow, flat-floored craters that scientists interpret have formed above a volcanic vent as a result of a violent expansion of magmatic gas or steam. Tuff cones range in size from 60 to 2000 m (200 to 6,500 feet) across and from 10 to 200 m (30 to 650 feet) deep, and are commonly filled with water to form natural lakes¹. Most tuff rings have low rims composed of a mixture of fragments of volcanic rocks and rocks torn from the walls of the volcanic conduit. The fragments may be held tightly together by cementing material, creating a rock you can break with a hammer. The images on the preceding pages clearly show that the surface morphology of Diamond Head is indeed ring-like rather than cone-like.

The oblique cross-sectional view below shows various parts of a tuff ring, just after it has formed. The essential component of a hydrovolcanic eruption is interaction between magma, entering through the conduit (C) and groundwater or surface water (A). Note that one side of the ring is higher above the ground surface than the other; this represents the down-wind direction.



Oblique cross section through a tuff ring. **A** is an aquifer intersected by the magma conduit, **C**. **I** are steeply-dipping inner wall layers of volcaniclastic material, and **O** are gently dipping outer wall layers. **L** is crater fill material.

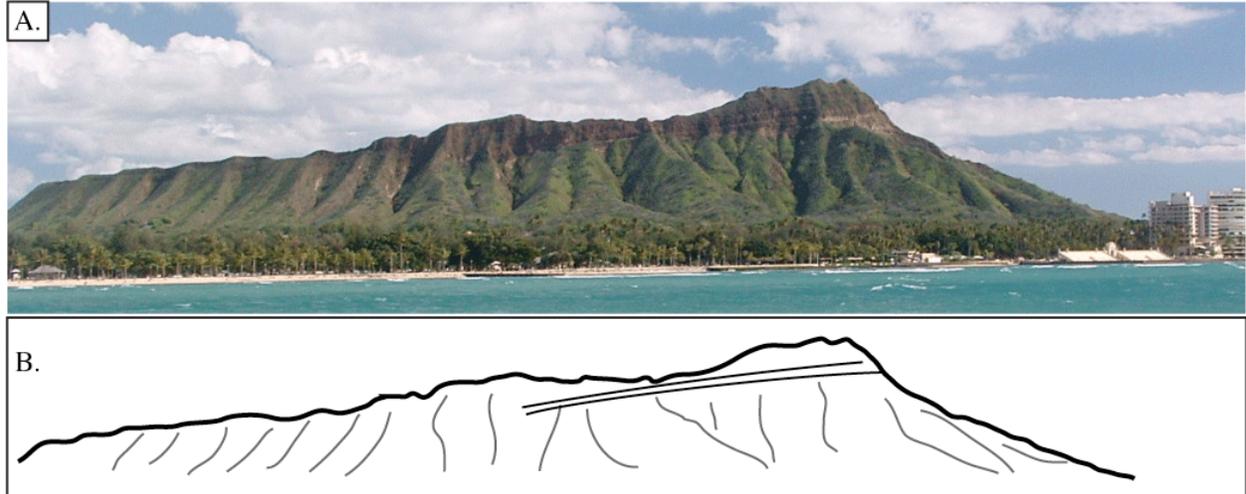
Tuff is a volcanic rock made up of a mixture of volcanic rock and mineral fragments in a volcanic ash matrix. Wherever there are explosive volcanic eruptions you can expect to find tuff. Tuff forms when some combination of fragmented magma (ash), conduit rock, and mineral fragments are blasted into the air, then fall to the ground as a mixed deposit.²

¹ Tilling, 1985, *Volcanoes*: USGS General Interest Publication

² U.S. Geological Survey and U.S. National Park Service Website, 2006, "Geology in the Parks."

Geological Observations

The photo below shows layers at Diamond Head dipping toward the center of the ring, yet the diagram on the previous page indicates that layers should both dip inward and outward from the axis of the ring.



A. Diamond Head as viewed from the northwest. B. Diagram highlighting the edifice profile, interfluvial (little ridges in the vegetated flanks), and bedrock layers.

1. Why do we see only inward-dipping layers at Diamond Head?

An **outcrop** is an exposure of bedrock or sedimentary deposits at the surface of the Earth. In Hawaii, soil and vegetation typically obscure the rocks. Outcrops are scarce and valuable for geologists.

2. Is this entire outcrop—rocks exposed from the shoreline to the cliff wall— made of the same material? Explain.

Consider the following checklist for describing clastic rocks, i.e., those composed of particles.

grain size: What is the range of particle sizes (in millimeters)?

shape: Are the particles equant (about the same length in all directions), elongated (like a pencil), or tabular (like a paperback novel)?

luster: Are the particles shiny like glass (vitreous), dull like soil (earthy), or pearly?

angularity: Are the particles jagged (angular) or smooth?

heterogeneity: Are all the particles in the rock about the same (in size, color, shape, and angularity), or are the particles highly variable?

induration: Are the particles stuck together (indurated) or does the rock come apart easily (friable)?

texture: Are the particles touching each other (clast-supported), or is there a cementing material between them (matrix-supported)?

bedding: Are the particles arranged in layers? If so, the unit is bedded. (usually, you can see the layers from a distance better than close-up.)

color: What are the tone (light or dark) and hue (e.g., green, purple) of the particles? What are the tone and hue of the rock as a whole?

5. Using the terms defined above, describe the floor unit, cutback unit, and roof unit using the table to organize your observations.

	floor	cutback	roof
grain size			
shape			
luster			
angularity			
heterogeneity			
induration			
support			
bedding			
color			

6. Scoop up a handful of sand from the beach. Sift it through your hand. What do you see?

	beach sand
grain size	
shape	
luster	
angularity	
heterogeneity	
color	

7. Do the particles of sand on the beach resemble the particles in the cutback layer?

similarities	
differences	

8. Which of the rock units is most likely to be the source of the beach sand? Why?

9. The cutback layer contains hard protrusions that resemble antlers. Are they made of the same materials as the rest of that layer? Use your hand lens to examine the interior, assuming that someone in the group can break off a piece. How may they have formed?

Piece together a geologic sequence of events

10. Do the brownish clasts within the roof unit resemble any other rock present at this site? If so, which rock, and how could they have come to be incorporated into the roof unit?

The boundaries between rock units are called “contacts. Contacts indicate a change in the type and/or source of material being deposited, and sometimes they also indicate significant breaks in time during which erosion occurs.

11. Do you see any evidence here for a time break between the units? Describe.

12. What is the origin of each layer? What sequence of geologic events produced the outcrop we see now?