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# The Waterfalls of Kauai, Hawaii

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# The Hydrogeologist

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# Where in the World?

This new section of the newsletter was inspired by the comments of Dr. Darryll Pederson in response to my picture in the "From the Editor" portion of the June 2010 newsletter. From that picture he was able to identify where I was, and provided some additional information regarding the significance of these and other waterfalls to the overall hydrogeologic system in Hawaii (see article below).
This section will include a picture provided by a division member along with a hint (if necessary) as to the location. If you think you can identify the location, send me an e-mail (andrea@kgs.ku.edu). I will identify the first few to guess the location (if any!) in addition to a short article identifying the location and hydrogeologic interest of the site in the following newsletter.
Pictures can be submitted to andrea@kgs.ku.edu. Please include the location and the basis for a short article regarding it's hydrogeoloic significance. Thanks!

**This edition's photo:**

Where in the World was Ed Harvey?

GSA Hydrogeology Division's 1st Vice Chair Ed Harvey shared this picture that he took on a recent trip.

Hint: Those little black shapes are some of the largest trout (rainbow and brook) in the world.

Think you know where Ed was? Send your guess to andrea@kgs.ku.edu

**Previous edition's photo:**

Location: Opaeka'a Falls, Kauai, Hawaii, USA

## The Waterfalls of Kauai, Hawaii

By Darryll Pederson

Everyone enjoys the sounds and sights of a tropical waterfall. They are the setting for romantic and action packed movies. Fantasy Island used Wailua Falls on Kauai to open their weekly TV series. From a different viewpoint waterfall origin and evolution has been attributed to a wide range of geologic processes. The Hawaiian Island's waterfalls and amphitheater-headed valleys have been cited by many as equivalent to similar features seen on Mars. After a number of years of studying these features on Kauai I offer the following thoughts and observations about Kauai's waterfalls and amphitheater-headed valleys.

Kauai is a shield volcano built from the ocean depths as the Pacific oceanic plate passed over a hot spot in the mantle. The other islands in the Hawaiian chain were formed in a similar manner. The main development of Kauai occurred on the order of

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5 million years ago. The Kauai volcano is composed of innumerable layers of rock formed from repeated eruptions of low- viscosity lava flowing down the 12-14 degree flanks. This lava, on cooling, formed basaltic rocks that with continued cooling resulted in fractures and joints. At times large cross-cutting fractures formed in the volcano were filled with rising magma. The magma cooled slowly in the fractures forming a dense and strong rock (dike). During periods of minimal or no lava flows the exposed basalts weathered rapidly to red clays in the tropic heat and moisture.

In aquifer terms the joints and fractures in the basalts represent major secondary-permeability routes for groundwater flow. The red soils represent low permeability as do the dikes. Because dikes cut across the multiple basalt flow layers and have different orientations they can be thought of as low permeability walls of an irregular box that leaks. An additional consideration is that the height of the shield volcano coupled with the trade winds has resulted in copious amounts of rainfall at the summit. The summit has been called by some “the wettest spot on Earth.” In spite of the high precipitation most rainfall infiltrates into the basaltic aquifer with discharge through innumerable springs on the island and springs in the submerged flanks of the volcano. Groundwater flow is radial from the top of the volcano. There is little direct surface runoff in the high areas of the island except where high weathering rates and low erosion rates has produced thick low- permeability soils. Because of the very active groundwater flow system groundwater is a major player in the development of drainage features on Kauai.

There are numerous waterfalls and a number of large amphitheater-headed valleys on Kauai. Many waterfalls are notable for protruding downstream under the mainstream of water flowing over the waterfall. Examples are Wiapo'o Falls (Figure 1) on the dry side of Kauai and Opaeka'a Falls (Figure 2) on the wet side of Kauai. Because the greatest headward development of the overall knickpoint morphology occurs where the water does not actively fall it begs the question of why is the greatest erosion not where the energy of the falls is concentrated, especially where rock juts out in the impact stream of Waipo'o Falls (Figure 1)? The wall of the upper and lower amphitheater of Waipo'o Falls is heavily vegetated to the right of the falls (Figure 3). In this area there is considerable groundwater discharge from groundwater recharged in the Alakai Swamp located on the high points of the shield volcano. Because of the radial groundwater flow, reflecting the sloping flank of the volcano, there is minimal groundwater discharge in canyon walls beyond points of intersection of the groundwater system and they appear dry.

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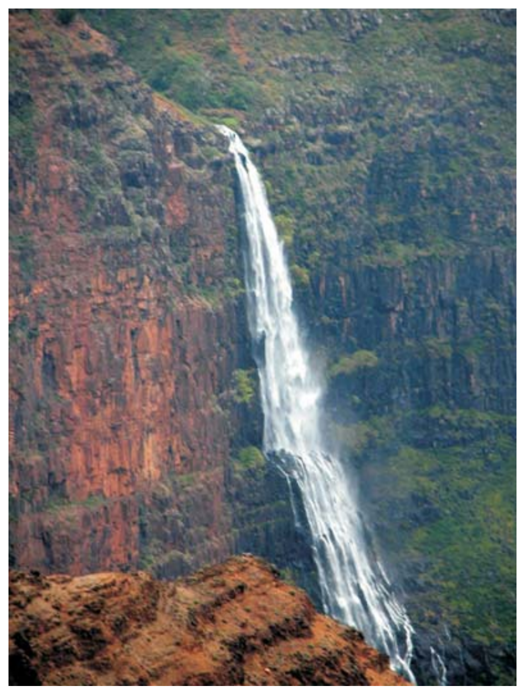

**Figure 1 - Close view of Waipo’o Falls. Photo by Darryll Pederson**


Do you have an interesting idea for a short scientific article? Perhaps an opinion on a new policy or technique? Any exciting news in your professional life? Upcoming conferece? An announcement of interest to the hydrological community? If so, why not publish it in The Hydrogeologist? Send your submission ideas to andrea@kgs.ku.edu

**STUDENTS, WE WANT TO HEAR FROM YOU TOO!**

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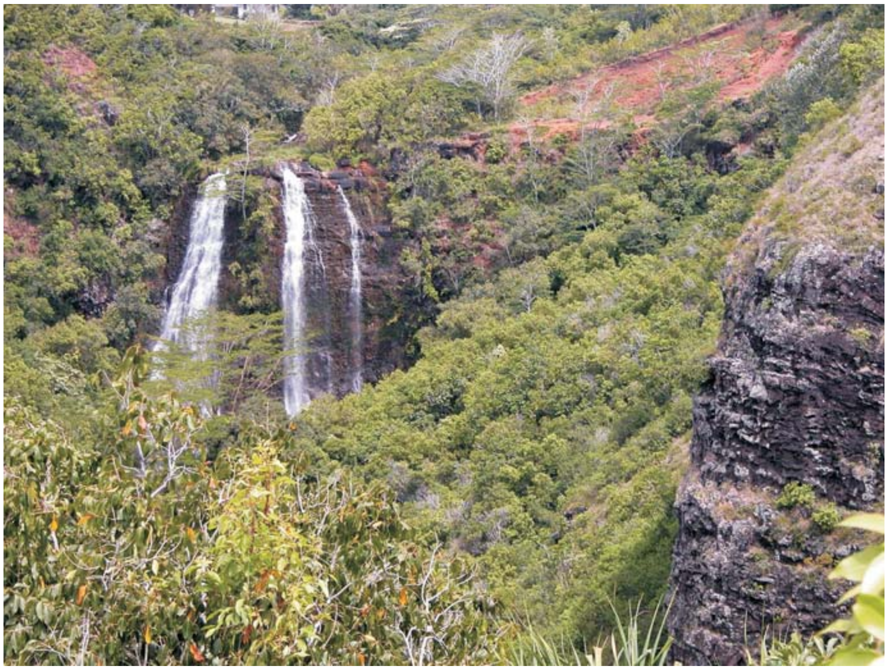

**Figure 2 - Opaeka'a Falls. Photo by Darryll Pederson**

**Figure 3 - Upper and Lower Waipo'o Falls. Photo by Darryll Pederson**

The growth of vegetation is the main driver of landscape weathering on Kauai. The mechanical action of roots breaking up rocks is extremely fast and effective. Fragmenting yields greatly increased surface area available for other type of weathering processes. Micro-environments around root fibers also enhance weathering processes through chemical and microbial effects. Finally, the presence of discharging groundwater supports the rapid and dense growth of vegetation and through hydrolysis weathering to clays. Waipo'o Falls protrudes because there is no vegetation under the waterfall stream and erosion rates are low as opposed to the right side of the knickpoint where there is ample vegetation and weathering rates are high (note - it is easy to transport clay weathering products). The amphitheater form (upper and lower falls) is developing in the direction of radial groundwater flow. Opaeka'a Falls has identical morphology and weathering processes. The main lower protruding feature (Figure 1) impacted by water flowing over Waipo'o Falls represents rock in place, not a boulder pile.

The Kalalau Valley on the Na Pali coast is headed by a large amphitheater face. There are no streams flowing over the face of the amphitheater. There are waterfalls, fed by springs, in the amphitheater face. There is also diffuse groundwater flow and associated dense vegetation on the amphitheater face. The Kalalau Valley amphitheater face has advanced headward in the direction of radial groundwater flow from the high Alakai Swamp. There are very striking and extensive flute developments in the walls of the Kalalau Valley and other valleys in the immediate area. There is an interesting interruption in the gradient of vertical sections of the walls of the Kalalau Valley. This interruption has a gradient along the walls of about 14 degrees or about the same as the groundwater gradient. This is a likely a groundwater story in itself.

At first glance Wailua Falls (TV's Fantasy Island fame, Figure 4) would appear to fit the model of undercutting by waterfall action. However, the "undercutting feature" is well above the elevation of the plunge pool and the main undercutting is to the left side of the waterfall. Figure 4 shows a clear elongation of the overall morphological feature associated with the plunge pool. The long axis of the elongation is parallel to the expected (radial) direction of groundwater flow. The undercutting unit has significant groundwater discharge. If one goes just downstream, there is another morphologic feature (incipient amphitheater?) that appears to be cutting in the direction of groundwater flow and widening the valley in the process. This feature has considerable groundwater discharge, dense vegetation growth, and considerable weathering of rock. The main channel of

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the Wailua River is very narrow along this reach with high rock walls.

Rapid headward incision of the Waimea Canyon occurred at an angle to the slope of the volcano flanks and has provided a local base-level change for the development of many knickpoint waterfalls such as Waipo'o Falls. The streams feeding these waterfalls have a large groundwater component representing recharge in the Alakai Swamp. In the lower elevations the Alakai Swamp sloping plateau has significant incision of streams fed by groundwater discharge..

All of the above features can be readily viewed, some from a distance. It is possible to get quite close to Wailua and Opaeka'a falls but the slopes are very steep. One should exercise extreme caution as the rock is brittle and should not be relied on for climbing support. The presence of water and clay also makes for very slippery conditions. The Kalalau Valley amphitheater and Waipo'o Falls can be reached from below by very long hikes. The Upper Waipo'o Falls can also be reached via a trail that starts just north of the second developed overlook of the Waimea Canyon. There are a number of trails through the lower parts of the Alakai Swamp.

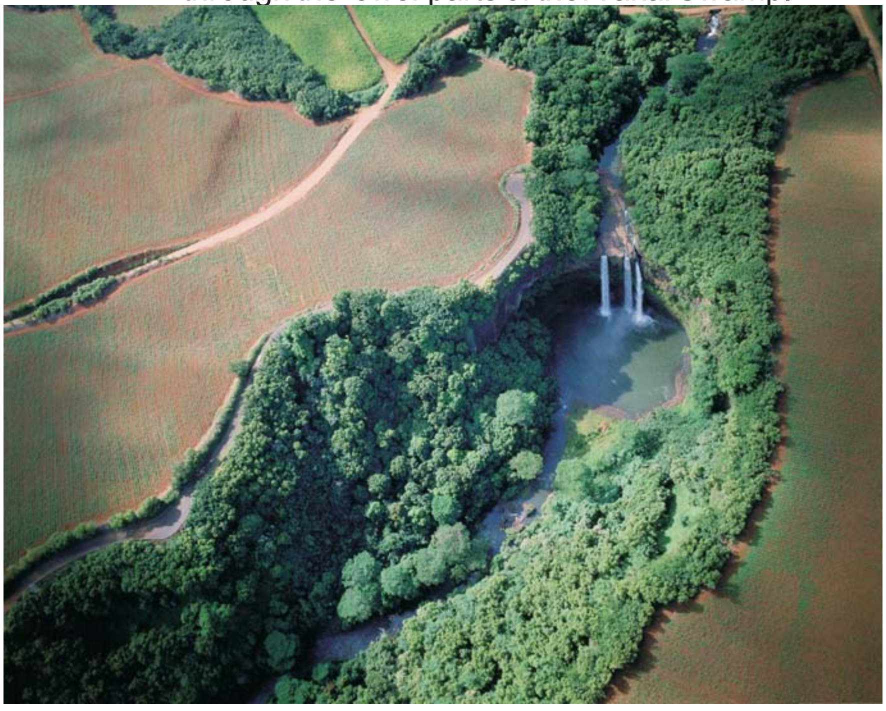

**Figure 4 - Air View of Wailua Falls. Photo by Douglas Peebles**

Hydrogeology Division Website: <http://gsahydrodiv.fiu.edu/>

# The Hydrogeologist

The Hydrogeologist is a publication of the Hydrogeology Division of the Geological Society of America. It is issued twice a year, to communicate news of interest to members of the Hydrogeology Division. During 1998, the publication moved from paper-based to electronic media. The electronic version may be accessed at: <*http://gsahydrodiv.fiu.edu*>. Members of the Hydrogeology Division who have electronic mail will receive notification of all new issues. Other members will continue to receive paper copies.

Contributions are material are most welcome, and should be directed to the Editor. Submission as a Word or WordPerfect document is most expedient.

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