CONDUIT FLOW OF WATER IN VOLCANIC PSEUDOKARSTS

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Abstract

The occurrence of steady state or flood pulse flow of groundwater in lava tube caves is widespread. The island of Hawaii is notable for several types of volcanic conduit caves. On Mauna Kea volcano, they are heavily eroded and extensively filled with mudflow and high velocity stream deposits. Others show much less modification. Unlike karstic conduits, these pseudokarstic conduits primarily function as leaky pipes; the presence or absence of adjacent aquacludes and porosity of adjacent volcanic materials largely determine their carrying capacity. In the presence of urbanization or intensive agriculture, they may be significant channels of pollution and contamination of groundwater and littoral springs.

Introduction

In recent decades, knowledge of lava tube caves and smaller lava tubes as conduits of flowing lava has become widespread. Much less known, however, is the function of these open tubes as conduits of flowing water: flood pulses, steady state flow, or both. The scientific literature is almost bare of recognition of this phenomenon. Yet scattered accounts and recent vulcanospeleological investigations clearly document its existance from Iceland to Tahiti, from Oregon to Madagascar. Their pseudokarstic flow differs fundamentally from that in karstic conduits. Yet in some basaltic regions, the public health implications of their flow volume and distribution must be considered much like those of their karstic analogues.

Differences between karstic and pseudokarstic conduit flow

Some of the difference between conduit flow in karsts and pseudokarsts reflects fundamental differences in their bedrocks. Because of the enormous porosity of many basalts, lava tubes are much leakier pipes than are karstic conduits. Thus they gather, contain, and transmit significant amounts of groundwater only under somewhat unusual conditions: clay fills in the tube and surrounding matrix, aquacludes (such as volcanic ash) immediately underlying the basalt flow, or the presence of an unusually dense lava containing the tube. Lava tube conduits can capture surface streams as do karstic conduits, but in the absence of such special factors, their water tends to leak away quickly. Conversely, groundwater leaks into lava tube conduits more readily than into similar conduits in consolidated limestones. And everything else being equal, water is less common in lava tubes than in limestone conduits because they form as readily in arid locations as in humid regions.

Types of flow in lava tube conduits

Both steady state flow and flood pulses occur in lava tube caves. A lava tube cave with seasonal or perennial steady state flow of glacial runoff is well known in Iceland, near the famous Surtshellir system. In Furna do Agua, Terceira, Azores, municipal waterworks capture and divert a perennial stream to supply a small town. In Oregon (USA), one of the headwaters of the Rogue River has been captured by a 100m segment of lava tube. In Utah (USA), water trickles into Duck Creek Lava Tube at several points, forming a stream which a rancher has dammed for domestic use.

In Hawaii (USA), during the last century a lava tube named Pukamaui captured the entire Wailuku River above the Hilo municipal water intake, and the cave had to be walled up.
In a populous suburb of the city of Hilo, flood pulses of much-visited Kaumana Cave are especially notable. These are of two types. After moderate rainfall (e.g., ca. 30 cm in 3 days), waterfalls spout at various heights along the corridor upslope from the main entrance. The resulting stream can be followed for several hundred meters before it sinks into a succession of crevices. Heavier rainfall floods lengthy sections of the cave to a maximum height of three to four meters and extensively redistributes sewage and trash which includes toxic and hazardous waste. Part of such floods emerges from an artificial lower entrance, whence it is diverted into a municipal floodwater drain; the remainder leaks into the peritubal groundwater. Especially heavy rainfall causes the cave stream to overflow these works and flood part of the subdivision.
Although of less public healh concern, bilevel Turtle Cave in the arid Kau District perhaps is more interesting hydrologically. An intermittent surface stream has cut a small gorge diagonally across and through the upper level at a point about 100 m downslope from the main entrance. Through an impenetrable orifice, extensive high velocity deposits including rounded boulders more than 10 cm in diameter have entered the lower level below the surface streambed. These flood deposits are well sorted. The lower end of the cave is obstructed by clay and mud.
On the windward (eastern) side of Mauna Kea volcano, several lava tube caves on moderate slopes have been heavily eroded by torrential stream flow and/or mudflows. In much of their courses, small scale features of lava tube caves have been obliterated. Large and small boulders and lesser stream deposits characteristically obstruct much of their courses. Where cave roofs have been destroyed, their trenches cannot be distinguished from other stream gullies and a fluvial pseudokarst is present. Most of these caves are in sparsely populated ranch country, but at least two are trash and sewage receptacles in populous Honokaa town.

Public health concerns

Although no serious public health problem has yet been traced to any such conduit in Hawaii, the presence of sewage and/or toxic and hazardous substances is worrisome. To date, none of their resurgences has been traced; presumably the ultimate resurgences are among the numerous beachline springs characteristic of tropical islands. Below Kaumana Cave, Hilo Bay is too contaminated for swimming. Here, fishing is permitted but I would not care to eat anyone's catch and the island's commercial fisheries have been decimated by undetermined factors.
At least for the city of Hilo, water tracing is needed as badly as in the infamous "natural sewers" of Bowling Green, Kentucky 50-odd years ago. A much higher level of public awareness is equally needed. An initial conference on this problem is scheduled in Hilo during the summer of 2000.