Radon concentration anomalies as possible precursors to pyroclastic flow events of Arenal volcano

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RESUMEN

El volcán Arenal es un estratovolcán activo, localizado en la parte norte de Costa Rica (10° 27' 48" N y 84° 42' 12'' W) a 1633 m sobre el nivel del mar.

Se realizaron mediciones de la concentración de radón en cinco estaciones ubicadas en el cono del volcán, utilizando detectores LR-115. Una de estas estaciones se encuentra directamente en una fuente termal. Se observaron anomalías en la concentración de radón antes de la expulsión de los flujos piroclásticos del 24,25 y 26 de marzo del 2001. La influencia de los parámetros externos sobre la emanación del radón son despreciables, ya que el más importante es la precipitación, la cual no presenta grandes variaciones, ni antes, ni durante los eventos ocurridos.

PALABRAS CLAVE: Radón, flujos piroclásticos, volcán Arenal.

ABSTRACT

Radon measurements were made at five stations located on Arenal volcano's cone, Costa Rica, using LR-115 detectors. The radon measuring stations were located on the active cone and one station was located directly over a hotspring. Radon flux anomalies occurred just before the pyroclastic flow event of March 24, 25 and 26, 2001. The influence of external parameters over radon flux is neglected, because the most important atmospheric parameter is precipitation, that at the time of occurrence of the pyroclastic flow event was at its lowest level for the year.

KEY WORDS: Radon, volvanic eruptions, pyroclastic flows, Arenal volcano.

INTRODUCTION

Arenal Volcano is a young andesitic stratovolcano with conical shape, located in the north central Costa Rica (10° 27' 48" N, 84° 42' 12" W), 1633 m. Arenal was not considered a volcano prior to its first historical eruption on July 29, 1968. On this day, a lateral blast and glowing avalanche destroyed two towns and killed 87 people (Saenz and Melson 1968). Three new craters (A, B, C) opened along an E-W fracture on the west flank. Shortly after the initial events, an effusive phase, characterized by the almost constant emission of blocky lava flows, started. From 1968 to March 1974, the activity was centered in crater A. In March 1974 the activity moved up to crater C (Malavassi, 1979). In June of 1975, a pyroclastic flow event occurred when a voluminous lava flow was emitted from crater C and was starting to descend the NW flank. These pyroclastic flows infilled in a few hours, the lower and middle valley of the Tabacón river watershed with block and ash flows (Van der Bilt *et al.,* 1976). After June 1984 strombolian eruptions often occurred at Arenal volcano (Barquero *et al.,* 1984). Pyroclastic flow events that occurred during 1987-1989 were generated by the fallback ejecta associated with large strombolian eruptions. After August 28, 1993 pyroclastic flow events occurred on May 5, 1998, October 26, 1999, August 23, 2000 and March 24-26, 2001. (Duarte and Fernández 2001). These events were caused by partial collapse of the crater rim at the active vent when a voluminous lava flow was being emitted.

METHODOLOGY

Measurements of radon concentration were carried out using a LR-115 (type 2 Kodak) detector. The detector is installed inside a 1 m long PVC vertical pipe at a distance of 30 cm of the lower extreme of the pipe. The empty area inside the pipe above the detector was filled with an isolator to avoid convection cells that could allow the formation of a gas flux that would alter the measurements as evidenced by García-Vindas (1999). Four stations were installed in dry sites and one station was installed on a hotspring (Figure 1). When measurements were carried out in springs, the detector was installed keeping a constant distance above the water surface. LR-115 films from the five stations were

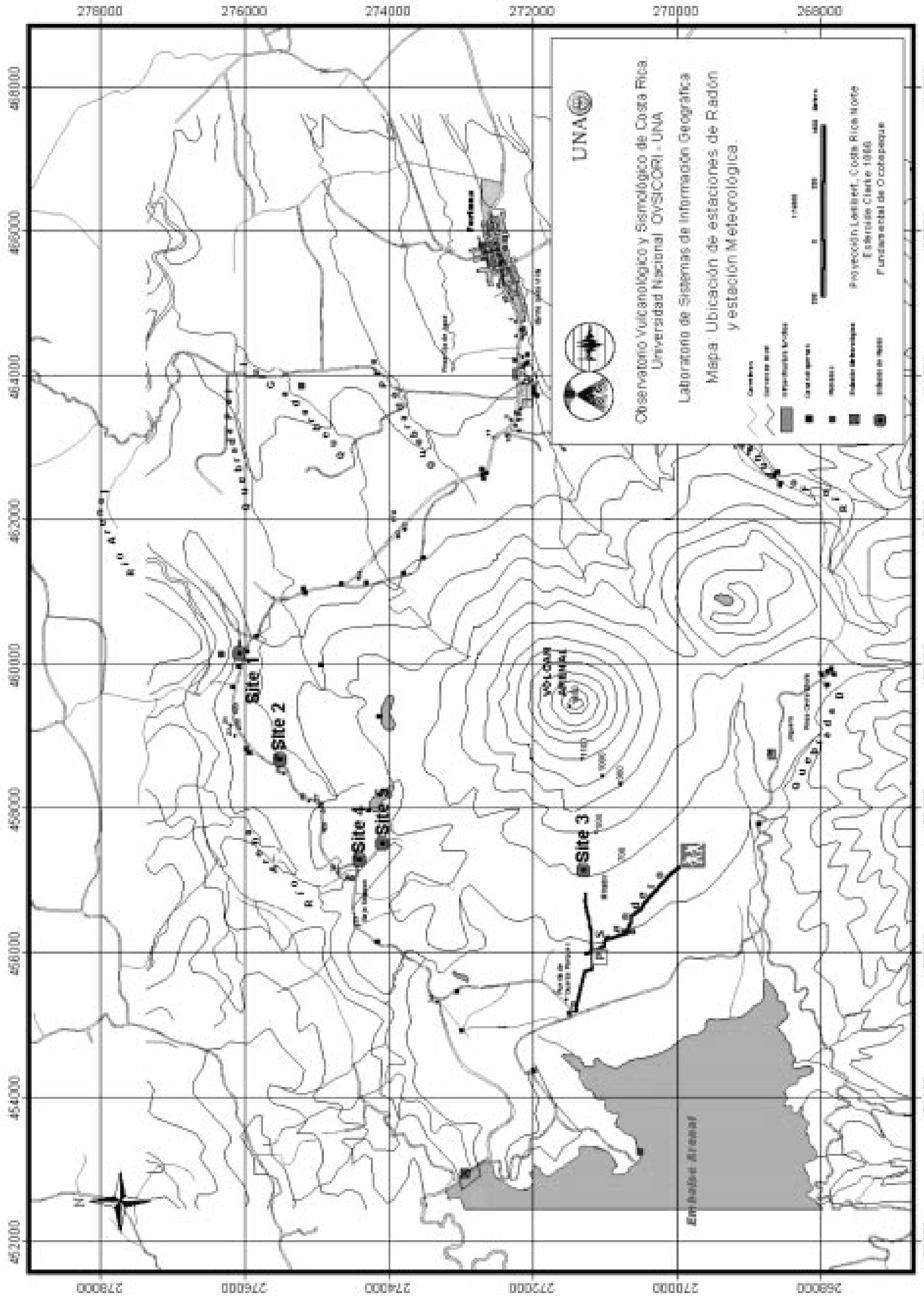

Fig 1. Location of five stations on Arenal volcano's cone.

collected every 15 days. In addition, precipitation measurements were registered monthly year around in order to consider the rain effect over the concentration of radon. Large anomalies in radon concentration have been directly correlated with the rain (García-Vindas, 1999 and 2000; Abbad *et al.,* 1996; Talwani *et al.,* 1980).

RESULTS

Figures 2-a, b, c, d show histograms of the concentration obtained at stations 1 ,2 ,3 and 4 located on the cone of Arenal volcano between January, 2000 and July, 2001. Figure 2-e shows the histogram from one detector installed in a hotspring after June 2000. Results from 4 stations show a normal behavior of radon gas from January to November 2000. Concentrations during these months show only ground noise variations without important anomalies. Station 5 gas concentrations showed a similar pattern as the other four stations, but only between June and November 2000. Detectors from station 1 during the period August-September 2000 were damaged by the chemical process of etching. Nonetheless, radon behavior shows a similar trend for the other 4 stations.

The concentration of radon increased for all stations after December , 2000 reaching a maximum between February and March 2001, just prior to the March 24-26 pyroclastic flow event. After the pyroclastic flow event, radon concentrations diminished, returning to the initial level in all stations.

Figure 3 shows monthly precipitation between January, 2000 and July 2001. During the first months of the year rain measurements were very low. Precipitation during the first three months of the year do not show large increments with respect to the other months. In addition, March is the month that records the least precipitation, so that the effect caused by this parameter on the radon concentration during this month would be minimal.

It is important to note that the anomaly registered at all stations started about 4 months before the pyroclastic flow event, so the possibility to successfully correlate this change with an atmospheric factor is limited.

CONCLUSIONS

Results obtained at all sampling stations show a clear correlation between the radon anomalies and the March 24-26 pyroclastic flow event. The precipitation effect can be

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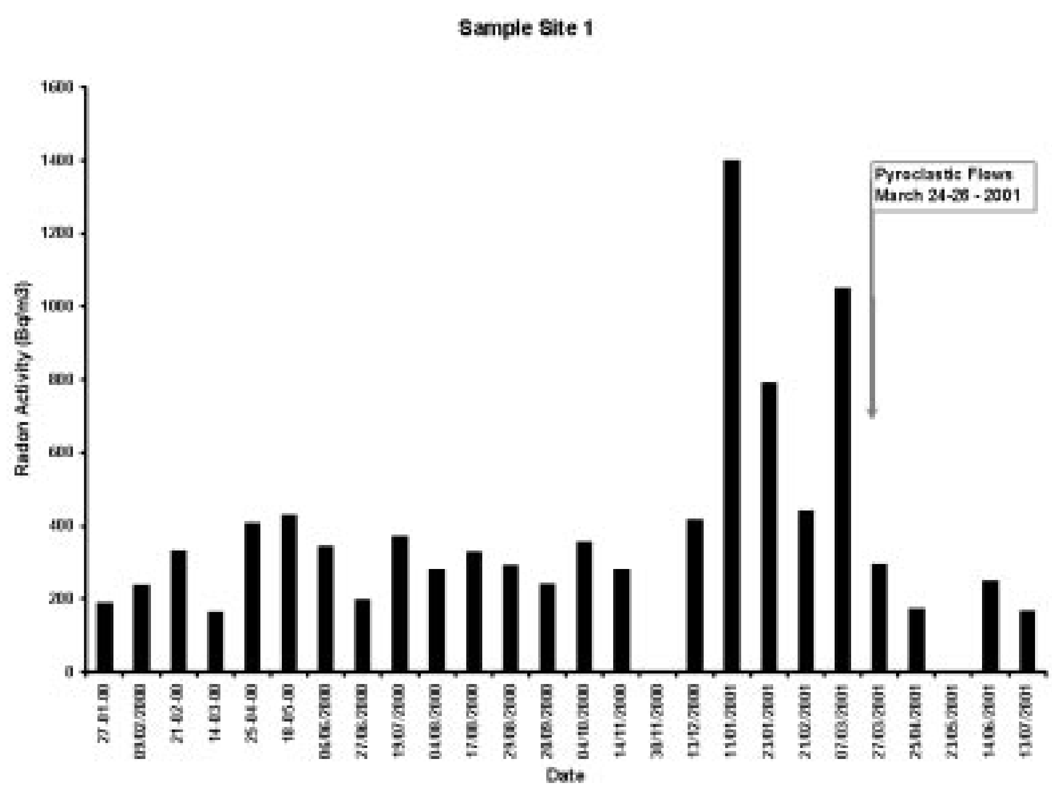
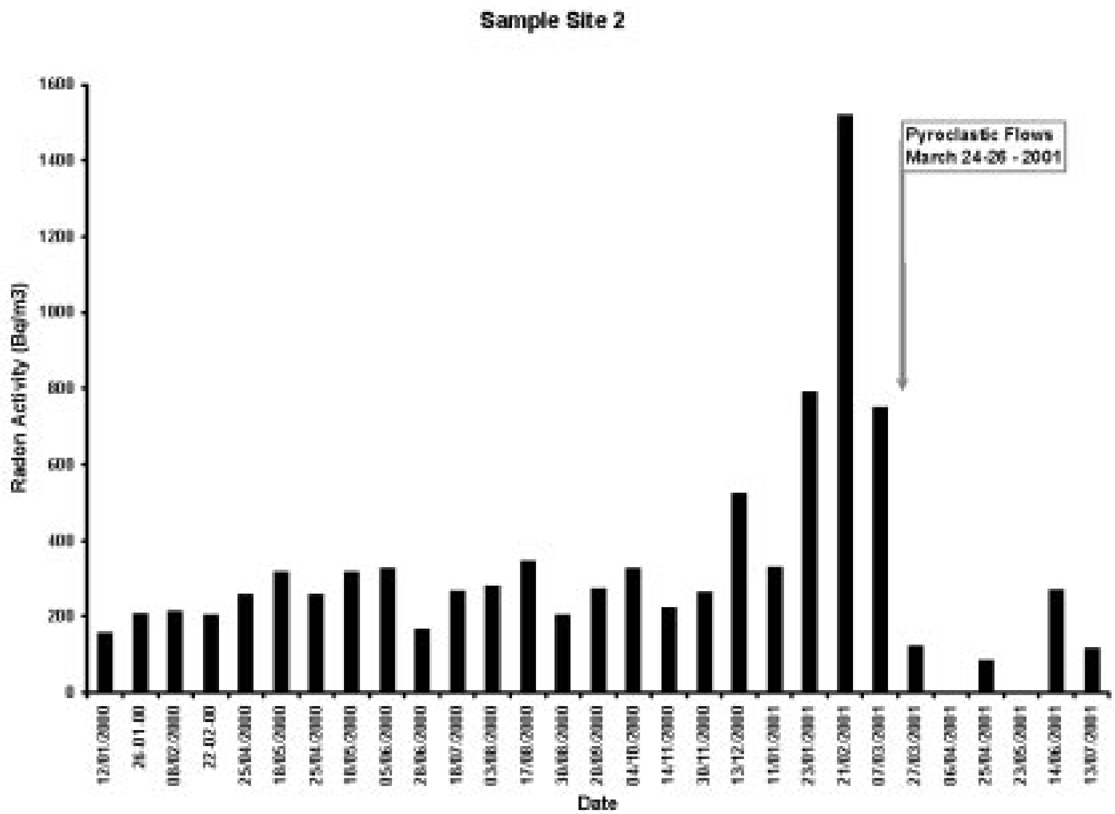


Fig 2. Histogram showing the concentration versus time concentration a) number 1, b) number 2, c) number 3, d) number 4, e) number 5.

b)



c)

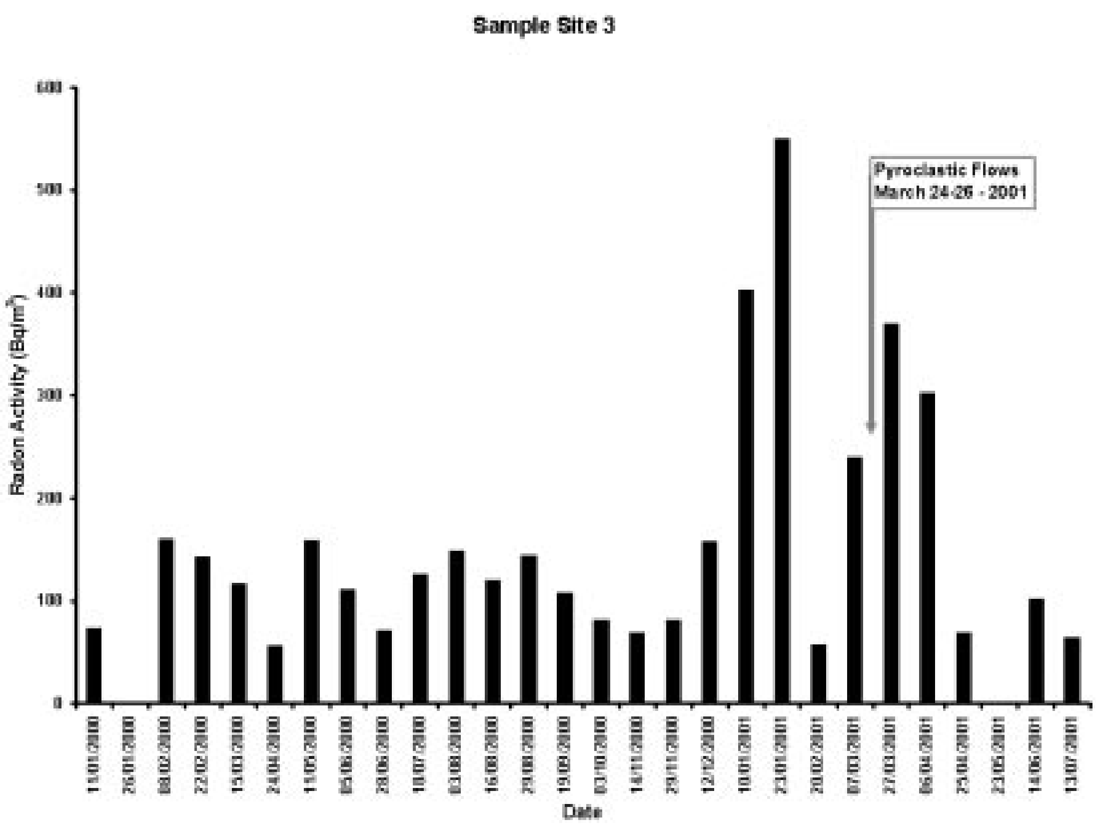
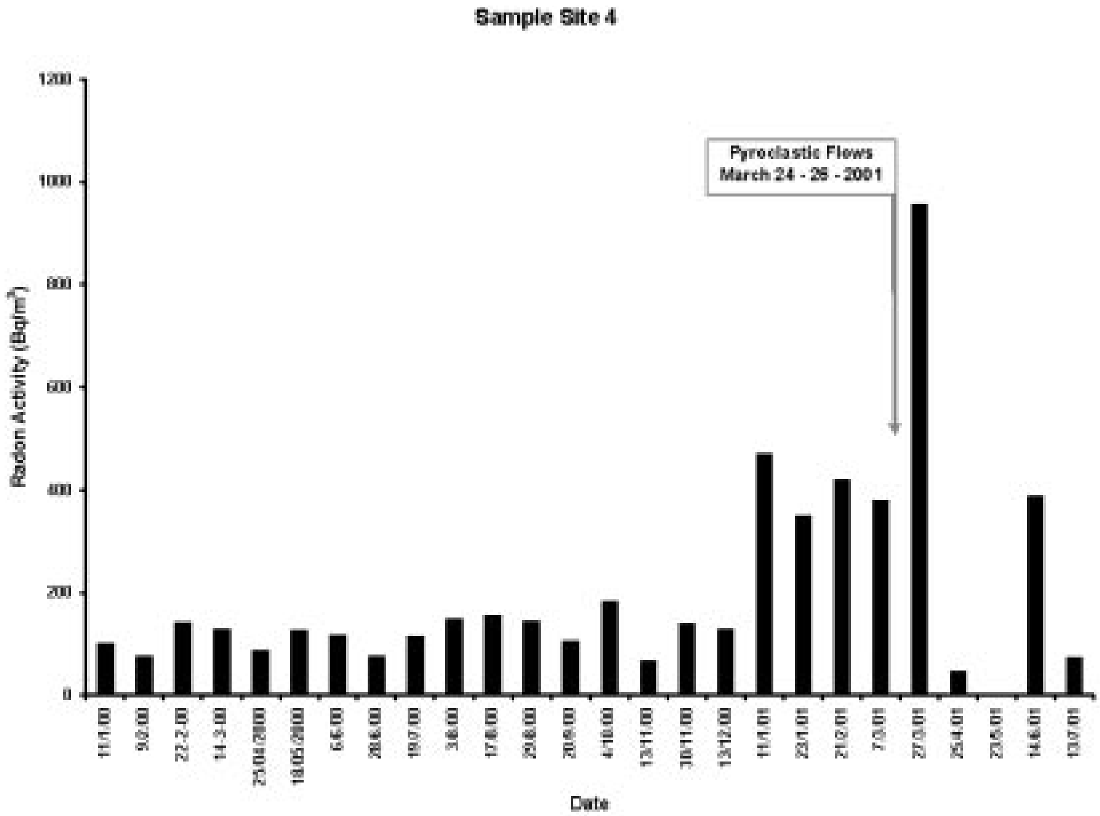
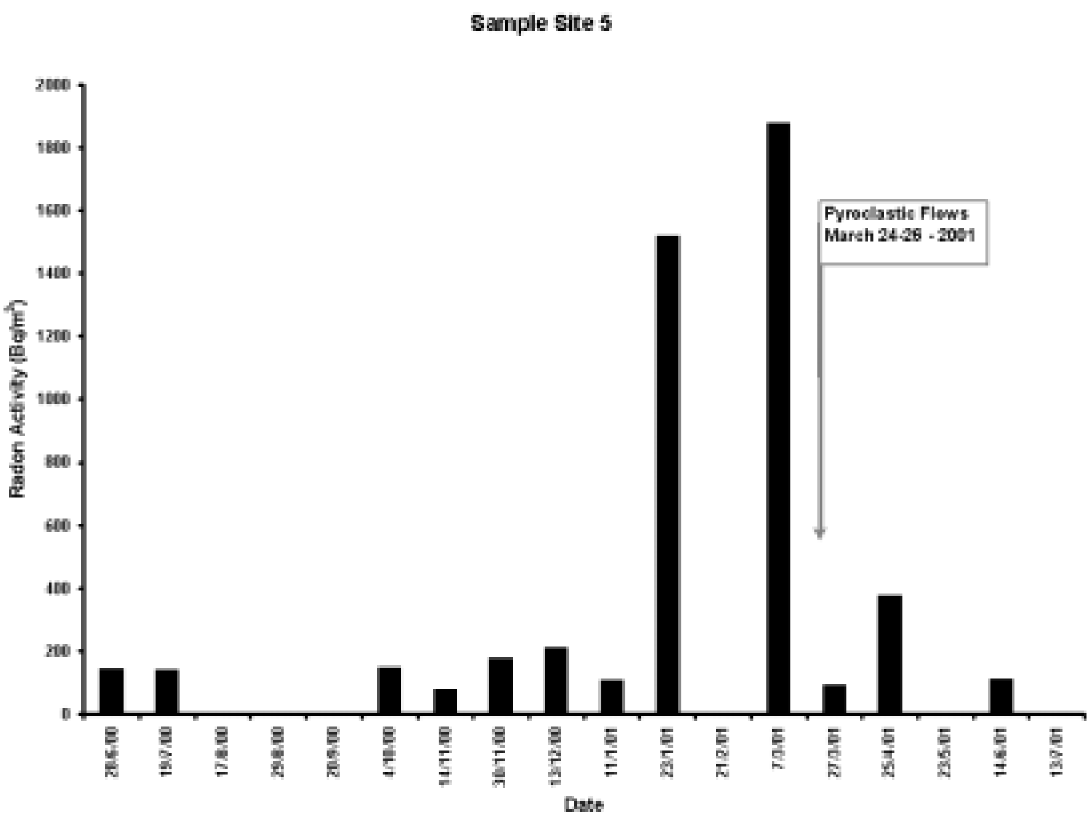


Fig 2. Continued.

d)



e)



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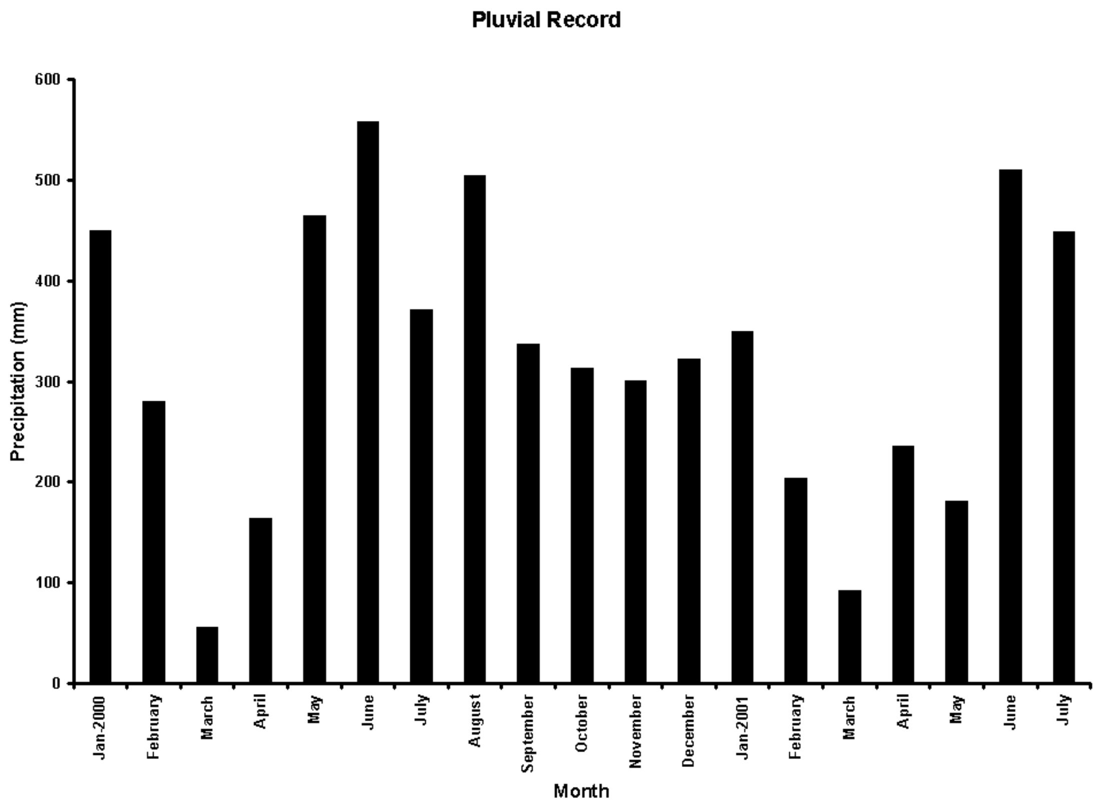

Fig. 3. Pluvial record of Arenal volcano and surrounding 2000-2001.

ruled out because it reached its minimum values just before the event (García-Vindas, 1999). Therefore, the observed anomalies in all stations are a good example of a precursory signal for the March 24-26 pyroclastic flows from Arenal volcano. Moreover, these signals are comparable in size and quality to the ones observed by Seidel *et al.,* 1988 and Notzu *et al.,* 1991.

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