Preliminary simulation study of Galeras Volcano structure using Muon Tomography.

Danilo Arturo 1, David Dueñas 1, Jairo Rodriguez 1, Jaime Betancourt 1, Alex Tapia 2, David Martínez 2

1 Universidad de Nariño, Pasto, Colombia.
2 Department of Basic Sciences, Universidad de Medellín, Medellín, Colombia.
3 IT Center for Accelerator and Particle Physics, Illinois Institute of Technology, Chicago IL, USA.

Abstract

Muon tomography is based on the observation of the absorption of muons in matter, or the ordinary radiography done by using X-rays. The interaction of cosmic rays with the atmosphere produces a cascade of secondary particles, known as atmospheric muons, which provide abundant source of muons. These particles can be used for various applications, in particular to study the internal structure of different volcanic edifices [1].

Using ENDF [4], we present a simulation of the cosmic ray and a scintillation detector that has been calibrated with a radioactive source. Subsequently, the simulation detector was placed at a previously studied point on the cone and the production of muon flux was realized at a certain angle and at different depths that cross the geological structure and hit the scintillation detector.

Introduction

The Galeras Volcano (GV) is a medium height (2.19 km) stratovolcano located in the eastern slope of the Southern Cordillera of the Colombian Andes. It is a typical example of a composite volcano which is characterized by its high threat to the populations living in its vicinity due to the interaction of its activity with the population [1].

The main eruptions have occurred during the last 30 years and have been characterized by the emission of large amounts of ash [2]. The most recent eruptions of September 2011 and June 2012 produced pyroclastic flows, lahars, and unroofed tephras, which are processes that can be observed in the dust deposited on the existing houses and in the streets of the city of Pasto. The volcano has a cone-shaped geometry that is approximately 4 km wide at its base and 2 km wide at its summit. The height of the cone is approximately 3 km. The GV has a complex volcanic system that consists of several lava domes and multiple cones, as well as a deep magma chamber located below the summit area. The magma chamber is characterized by a high content of silica (75-80 wt%), which is typical of andesitic-monzonic magmas [3].


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\text{Cone of GV: } V = \frac{1}{3} \pi r^2 h
\]

where \(V\) is the volume of the cone, \(r\) is the radius of the base, and \(h\) is the height of the cone.

For the implementation of the simulation, we used a 3D model of the GV and its surroundings in GeoIC [1], which is a software that allows for the modeling of complex geological structures. The simulation was performed using the EGSnrc code [4], which is a widely used code for simulating the transport of secondary particles in matter. The simulation was performed with a grid size of 50x50x50 m, with a total of 500,000 particles. The simulation was run for a period of 1000 seconds.

Results

We simulated the cosmic ray flux and the production of muons at different depths and angles. The simulation results show a high muon flux at the surface of the GV and a decrease with depth, which is consistent with the expected behavior of muons in matter. The simulation results also show that the muon flux is highest at the summit of the GV and decreases with distance from the summit.

Conclusions

We conclude that muon tomography is a promising technique for studying the internal structure of volcanic edifices. The results obtained in this study show a high potential for applications in geophysics and geology. Future studies should be aimed at improving the accuracy of the simulations and expanding the database of cosmic ray simulations.

References