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Citation: AIP Conference Proceedings **1677**, 080005 (2015); doi: 10.1063/1.4930736
View online: http://dx.doi.org/10.1063/1.4930736
View Table of Contents: http://scitation.aip.org/content/aip/proceeding/aipcp/1677?ver=pdfcov
Published by the AIP Publishing

Numerical model of heat conduction in active volcanoes induced by magmatic activity

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Abstract. We study the heat transfer mechanism of active volcanoes using the numerical thermal conduction model. A 2D model of volcano with its conduit filled by magma is considered, and acts as a constant thermal source. The temperature of the magma activity diffuses through the rock layers of the mountain to the surface. The conduction equation is solved using finite-difference method, with some adaptations to allow temperature to flow through different materials. Our model allows to simulate volcanoes having dikes, branch-pipes, and sills by constructing the domain appropriately, as well as layers with different thermal properties. Our research will show the possibility to monitor magma activity underneath a volcano by probing its surface temperature. The result of our work will be very useful for further study of volcanoes, eruption prediction, and volcanic disaster mitigation.

Keywords: finite-difference, volcano, heat-conduction
PACS: 02.60.Jh, 02.70.Bf, 44.10.+i, 66.30.Xj

INTRODUCTION

Nowadays, the activity of volcanoes is monitored using many accurate measurement methods, spreading from ground-based methods, such as seismic, to the satellite-based methods. This methods are mostly based on the mechanical events and the motions of ground of the surrounding. The basic technique is detecting the unrest of a volcano based on the change of vibration (tremor) and the position monitoring. The latest can be accurately done with the help of satellite imaging and global positioning systems [1]. A small deformation of the ground around a volcano may reflect the pressure change beneath the surface due to the motion of fluid magma.

The methods described are used in an early warning system of the possible eruption. After the activity is identified, further analysis of the activity can be carried out. Among those analysis methods are the release of gas and its chemical compounds, and the temperature change of the water and ground. From these data, the time and type of eruption might be predicted. However the accuracy of volcanic event prediction is still questionable, since we deal with a lot of parameters, accompanied by their uncertainty. Thermal measurement of an active volcano is a regular procedure to track the heat fluctuation. Together with the chemical analysis of the released magmatic gases, one can use the data to obtain a clue to the type of eruption.

The failure of volcano activities prediction can be fatal. It posses scientific complexity and a direct social and environmental effects. To over-estimate it would loosen the confidence of the people living around a volcano. Otherwise fail to give eruption prediction would end in a suffering catastrophe. To assist obtaining more reliable activity predictions, the help of computer is conceivable. Many works on modeling the interior of volcanoes and the dynamics of magma is done using computer algorithms. The flow of lava and magma was numerically modeled in [2], where the dynamics of magma inside the conduit and the ejection of volcanic ashes is thoroughly studied. A numerical study of the volcanic earthquake was also modeled numerically in [3]. The simulation was performed to increase the accuracy of volcanic events forecasting.

In this work we modeled the heat transfer phenomena of a volcano, by assuming an isotherm conduit filled by magma. We analyzed the temporal temperature distribution on the volcano's surface according to the modeled conduit shape. The result of the simulated model will be the base of further research on monitoring the surface temperature of a volcano, which will be useful in volcanic disaster mitigation.

The 5th International Conference on Mathematics and Natural Sciences
AIP Conf. Proc. 1677, 080005-1–080005-6; doi: 10.1063/1.4930736