Differential Eruption Styles of Volcanics on the Moon

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Abstract - *Crystallization of a lunar basalt and cooling rates change with temperature. The Velocity and Pressure of the volcanoes on lunar surface is modeled using a code for flow of magma in the volcanic conduits. The code computes steady, isothermal and multiphase non-equilibrium flow. Further, we separately solve both mass balance and momentum balance equations for a gas phase and a dense phase, which represents flow of magma inside a vertical conduit.*

Key Words: Crystallization, Melting, Lunar surface, Lunar volcanic conditions, Eruption, Model.

1. INTRODUCTION

Studies indicate that the water content in the parent magma of mare basalts is at least 10 times lower than that of the volcanic glasses. More volatile-rich source of the picritic glasses than that of the mare basalts in the lunar interior must have influenced the liquidus temperature, mantle melting and viscosity of the magma, those in turn would have reflected the nature of different mare volcanism through space and time. Experimental studies showed that the volatile-saturated mantle melted at much lower temperature than the dry mantle.

The lunar gravity is only one-sixth that of Earth. So, when the eruption occurs on lunar surface, most of the erupted crystals will rise above the surface instead of depositing on the surface. The pressure of those eruptions is necessary to know the related things. The basalt fire fountain eruption on Earth is very well-known. Below the effects of different volatile content of the magma between mare basalt and the volcanic glass have been tested. Here we discuss about the widespread presence of volatiles in the lunar interior that could have influenced differentially to the physical and chemical properties of the mare source regions and hence the nature of mare volcanism on the Moon.

2. Related Work

An overview of the lunar mare basalt magmas with the new data on the crustal thickness and density is explained [1].A theoretical analysis of the generation and eruption of basaltic magma on the Moon is given. Density contrasts between the bulk mantle and regions with heat sources. Steady flow in a constant diameter duct gives result in elliptic equations, which define boundary value problem. The spatial step for integration of the system of ordinary differential equations is determined by the code. The numerical scheme is based on a predictor-corrector solver algorithm [2].

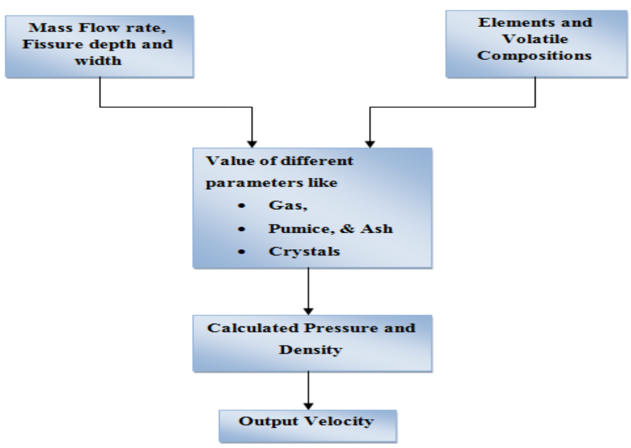
The formation of glass beads on the moon occurs by ductile fragmentation above the vent. The driving force for fire-fountain eruptions occurs by exsolution of dissolved H_2O and CO_2 gases dissolved in the magmas [3]. Similar eruptions of basaltic magma on Earth were found in Hawaii [4]. It describes that volcanic eruption modeling can be used to find the duration of process, exit mixture velocity, mixture density, gas volume fraction, mass-flow rate etc.

3. VOLCANIC CONDUIT MODEL

Presence of volatiles in the lunar interior could influence the physico-chemical conditions of the lunar magma, e.g., the liquidus temperatures, mantle melting and viscosity of the magma [3, 5, 6, 7] that would be reflected in the nature of basaltic volcanism on the moon. Experimental studies showed that the volatile-saturated mantle melted at much lower temperature than the dry mantle and also extend the range of melting. Using olivine-liquid thermometers, we infer a depression of dry liquidus by 20°C of the mare basalt with addition of 300 ppm of water and 35°C of the volcanic glass with addition of 1200 ppm water in their respective bulk compositions. The viscosity of magma controls the transport dynamics in the silicate magmas [8].

The change of viscosity values in dry versus hydrous parent magmas was calculated and eruption of the lunar volcanic glasses were modeled using the fluid dynamics code of [2] using reasonable values for density of magma, oxygen fugacity of lunar mantle, and fissure depth and diameter [3].

4. Proposed Solution and result analysis



5. Result

The eruption style of the lunar volcanic glasses was modeled using "CONDUIT4" fluid dynamics code of [2] and considering and modifying mathematical and physical modeling of [2]. There are two phases: the gas phase and the dense phase in the vertical conduit. The Gas phase is made up of water and carbon dioxide in major proportion with subordinate amount of liquid phase. The Dense phase is made up of liquid phase, in which we have incorporated dissolved water and carbon dioxide in the code. The code gives the velocity changes when the level of the gaseous phases is changed. Since the sum of masses (wt %) of oxides of other elements is irrelevant – only relevant being their relative abundances – we defined them as mass percentages, and presented them as input value to a fraction of one.

It has been noticed that the flow rate and exit velocity of the volcanic materials were enhanced significantly by adding water to the dry parent magma and assuming 0-500 ppm of CO_2 in the magma, leading to fire-fountain on the surface of the Moon, whose gravity is six times less than on the surface of the Earth, and the surface atmospheric pressure is ~ zero. The flow rate changed from 10 kg/s to 70 kg/s in 1m diameter fissure and 2000 kg/s to 18000 kg/s in 4m diameter fissure from dry to 1200 ppm wet magma, indicating a trend towards the more eruptive nature. In the terrestrial conditions, mass discharge rate is of the order of 10^4 to 10^6 kg/s in the Hawaiian type fire-fountain eruption. Because of comparatively high viscosity of the basaltic lava flows and continuously changing physico-chemical characteristics of the mare basalts throughout the stages of crystal fractionation similar simulation of the flow dynamics of mare basalt was not possible, this can be an intrinsic limitation of this model calculation. However, given the lava flow characteristic of mare magma and low concentration of water, the flow rate and exit velocity would have been much slower than that of the volcanic glasses parent magma, which had a homogeneous chemical composition with very low modal abundance of solid crystals during ascent. The main driving force for the lunar magma eruptions was proposed to be by oxidation of reduced carbon (graphite) and the fragmentation of the melt [3, 5, 6, 7]. This result suggests that the parent magma of the volcanic glass was sufficiently water-rich to generate the fire-fountain at the lunar surface, with or without the presence of carbon.

Sr. No.	H_2O (wt %)	CO_2 (wt %)	Exit Velocity(m/s)	Exit Mixture Density(kg/m^3)
1	0.12	0.05	308.5	0.5487e+05
2	0.12	0.02	296.3	0.4908e+05
3	0.12	0.00	283.5	0.45617e+05
4	0.05	0.05	214.5	0.27006e+05
5	0.05	0.02	198.6	0.21275e+05
6	0.05	0.01	194.0	0.19298e+05
7	0.08	0.005	233.1	0.30496e+05
8	0.08	0.0005	230.1	0.29787e+05

Table-1: Values of Other Input Parameters with velocity variations

6. CONCLUSIONS

The method has given the output results in less time and has given the velocity of the volcanic conduits. When the H_2O + CO_2 Mixture is given, the output generated Velocity is in the range of 198 m/sec to 308 m/sec, depending up on variable volatile proportions as mentioned in Table 1. The velocity value varies as the H_2O level decreases. However, the code needs to be modified with absence of H_2O or depending on the speciation of C-O volatiles.

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