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A3_6 Hot Stuff

A. Yeo, H. Routledge, J. Lewis, D. Meggi

Department of Physics and Astronomy, University of Leicester, Leicester, LE1 7RH

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Abstract

In the hit game "Minecraft", lava poses a huge threat to your progress as well as being a valuable resource. In this paper we analyse how lava is programmed into Minecraft and attempt to categorise it as a mafic or felsic lava. Since lava in the game moves at around $\frac{2}{3}ms^{-1}$, the lava shares similar properties to a basaltic lava at around 1160° Celsius, with a coefficient of viscosity of around $6.82\text{x}10^2 Pas$ and is therefore most likely mafic. This calculation however assumes the lava flow in game is non-turbulent and does not explain why obsidian is formed when the lava interacts with water.

Introduction

To determine the classification of Minecraft's lava we need to compare the real life properties of various forms of lava to the ones seen in the game. For this paper we focused on flow speed and viscosity. The properties of lava depend on its mineral composition, primarily the percentage of silicon dioxide plays a critical role in the lava's temperature, viscosity and density. Mafic lava is mostly formed of minerals that are non-silicic, forming lava with density of around $3000kgm^{-3}$, at high temperatures of around $1100° - 1200°$ Celsius. Felsic lava on the other hand is dominated by Silicon dioxide, forming up to 70% of its composition. This lava is typically cooler at around 800° Celsius and has a lower density of approximately $2700kgm^{-3}$ [1][2].

Felsic lava is also more viscous than mafic lava, meaning it will have a slower flow velocity. Due to it's viscosity, felsic lava will often be erupted in violent explosions as gases are unable to escape. By calculating the flow speed of these different lavas, we can compare them to the speed of flow of lava within the game to see which is most accurate.

Discussion

Lava in Minecraft will always flow at around 1 block per 1.5 seconds. Since each block in the game is a $1m^3$ cube, this means Minecraft's lava has a flow speed of $2/3ms^{-1}$. To calculate flow velocity of the lava in the real world, we can use Jeffery's formula given below, which describes the flow of a non-turbulent lava [3]:

$$v = \frac{h^2 g\rho \sin(\theta)}{3\eta} \tag{1}$$

Where v is the flow velocity, h is the depth of lava, g is the gravitational acceleration (taken to be $9.81ms^{-2}$), ρ is the density, θ is the angle the lava flow makes with respect to the ground and η is the lava's viscosity. In the game, since again each block is a $1m^3$ cube, we can use real-life to in game measurement ratios to find the angle lava spreads at. Figure 1 shows how this measurement was taken and in this case the angle

θ was found to be 11.77° and the depth h was found to be $0.208m$. Since there are no explo-

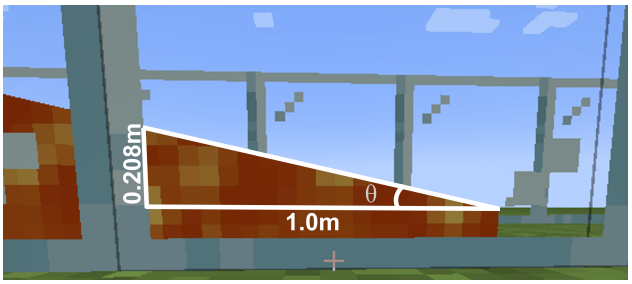

Figure 1: The angle of lava flow in Minecraft

sions seen in Minecraft, we started by calculating the flow speeds of a mafic lava. This means setting the density ρ to $3000kgm^{-3}$ and finding values for the coefficient of viscosity, in the case taken from a basaltic lava.[3]

Temperature (° Celsius)	Viscosity (Pas)	Flow velocity (ms^{-1})
1400	35.3	11.98
1340	65.0	6.51
1320	82.0	5.16
1280	$1.34x10^2$	3.16
1220	$2.96x10^2$	1.43
1160	$6.82x10^2$	0.62
1160	$1.36x10^3$	0.31

Table 1: Data for a basaltic mafic lava showing viscosity and flow velocity at various temperatures

As can be seen from the table 1, the viscosity and flow rate of the lava increases at higher temperatures as expected, due to higher thermal energies. Minecraft's flow velocity is very comparable to that of a basaltic lava at a temperature of 1160° Celsius with a coefficient of viscosity of $6.82x10^2Pas$. There is however a case to be made for the lava being felsic in composition. In the game, when lava interacts with water, it can create obsidian, which in the real world is a volcanic glass dominated by silica. This means obsidian is formed when felsic lava is rapidly cooled such as when in contact with water. This is most likely either a mistake on the developer's part or a simplification for the game however. Since felsic lava is much more viscous than mafic lava ($\eta > 10^6$)[4] its flow speed is much slower making it an unsuitable comparison to the game. We can approximate the flow speed of felsic lava using equation 1 and the the same values of h and θ used earlier, except here the density ρ is lower at $2700kgm^{-3}$ and it has a higher viscosity of orders 10^6Pas. This gives a flow speed of around $10^{-4}ms^{-1}$, far slower than the flow seen in game.

Conclusion

From the data in table 1, the closest real life approximation of Minecraft lava is a mafic basaltic lava at a temperature of a little greater than 1160° Celsius to create a flow velocity of approximately $\frac{2}{3}ms^{-1}$. Felsic lava is too viscous to have a comparable flow speed, despite the game featuring the formation of obsidian when the lava cools rapidly when in contact water. This paper however does approximate a laminar flow of the lava in game, it is possible that at higher viscosities such as in felsic lava, turbulent flow becomes an important factor. Further work could be done on approximating the turbulent flow of lava as well as looking at intermediate lava, which lies in-between the extremes of mafic and felsic.

References

[1] `http://sci.sdsu.edu/how_volcanoes_work/Controls.html` [Accessed 22 November 2021]

[2] `https://laulima.hawaii.edu/access/content/group/dbd544e4-dcdd-4631-b8ad-3304985e1be2/book/chapter10/volcanoes.htm` [Accessed 22 November 2021]

[3] R. L. Nichols, *Viscosity of Lava*, The Journal of Geology, Vol. 47, No. 3 (Apr. - May, 1939), pp. 290-302

[4] M. O. Chevral, H. Pinkerton and A. Harris *Measuring the viscosity of lava in the field: A review*, Earth-Science Reviews, Volume 196, September 2019, 102852