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Playing 'The Floor is Lava' in Real Life

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Abstract

The popular children's game 'the floor is lava' seems entertaining when played using only the imagination, but it is not widely known what the effects would be if this game were to be played using real lava. This paper investigates whether playing this game in real life would be possible and what effect that would have on the human body.

Introduction

Most people have played or heard of 'the floor is lava', a popular children's game which requires one to imagine that the floor is made of lava and thus that it cannot be touched. The floor being made of imaginary lava means that one must find alternate methods of traveling from one side of a room to another, resulting in time spent jumping between items of furniture and climbing on various structures in order to avoid an imaginary, yet apparently fiery, death. As an adult, possibly lacking the imagination once possessed as a child, one might start to wonder if it would be possible to recreate this game using real lava in order to reclaim one's youth without putting in the mental effort required to imagine that the living room floor is made of molten rock. This paper seeks to investigate this possibility by taking the many properties of lava into account and determining whether a human would be able to survive in its presence for the duration of the game.

Biological effects of gases produced by lava

Assuming that the floor being used for this game has spontaneously transformed into lava, rather than arriving via an erupting volcano, we can also assume that the huge concentrations of gases produced during a volcanic eruption would not be present in the atmosphere. However, the lava itself would likely produce gases of its own, independent of any volcano.

The main gases produced by lava are water vapour and carbon dioxide (CO_2) [1], the latter of which could be quite dangerous if we were to play this game in an area with an uneven floor. This is because CO_2 is heavier than air so it would displace the air and accumulate in the lowest points of the room. In these areas, a person would experience a rapid loss of consciousness, followed by asphyxiation due to the lack of oxygen [2]. People in areas with lower concentrations of CO_2 might experience difficulty breathing, dizziness, and impaired coordination before eventually losing consciousness [3], all of which would make playing this game quite difficult.

Examples of other gases which are produced in minor amounts by lava are sulphur dioxide (SO_2), hydrogen sulphide (H_2S), and occasionally hydrogen fluoride (HF) [3]. In small amounts, these gases can cause irritation of the mucous membranes of the eyes, nose, and throat. Long exposure to low concentrations of these gases can cause similar breathing issues to those experienced with lower concentrations of CO_2 as well as dizziness and irritation of the respiratory tract. Exposure to HF can be especially dangerous as it is a strong irritant and larger concentrations of it can be highly poisonous [3]. These gases are not usually produced in large amounts from lava alone, though, so as long as the game being played does not last for several hours, it may be possible to avoid the most serious of these effects.

Air temperature above lava

In order to see what effect the extreme temperatures of lava would have on the human body, we can calculate the temperature of the air above the lava in the house that the game would be played in. To do this we use the following equation:

$$Energy\ lost\ by\ lava = energy\ gained\ by\ air$$
$$-m_{lava}c_{lava}(T_i - T_f) = m_{air}c_{air}(T_f - T^i) \qquad (1)$$

Where m is mass in kilograms, c is the specific heat capacity (in J kg^{-1} K^{-1} – 0.84 for lava and 1.01 for air [4]), T_i is the initial temperature in Kelvin (1523K for lava [5] and 293K for air [6]), and T_f is the final temperature in Kelvins. The assumptions that we need to make in order to use this equation are that the house is insulated to the extent that it becomes a closed system (meaning no heat can escape), the floor is made of a common type of lava, basalt, to a depth of 0.5m, and that the room being used for the game is 3m tall with a floor area of $1m^2$. We also need to calculate the respective masses of lava and air present in the room at the time of the game, which is done by multiplying their densities by their volumes. The density of lava is $2700\ kg\ m^{-3}$ [7] which gives it a mass of $1.35 \times 10^3\ kg$, and the density of air is $1.204\ kg\ m^{-3}$, giving it a mass of $3.612\ kg$.

Using these values, we can solve equation (1) to give us a final temperature of 1519K, which would also be the temperature of any room with the same height and depth of lava but different floor area. This tells us that the game could not actually be played indoors as the temperature would be too high for a human to tolerate. Because of this fact, we may want to consider the possibility of playing this game outdoors, under the assumption that a more open space would cause the temperatures above the lava to be much lower, allowing the players to actually survive.

To calculate the rate of temperature change above the lava while playing the game outdoors, we can use the Stefan-Boltzmann law:

$$P = \epsilon\sigma A(T^4 - T_c^4) \qquad (2)$$

In this equation, P is equal to power in Watts, ϵ is the emissivity (0.9 for lava [8]), A is the area above the lava, σ is $5.67 \times 10^{-8} W\ m^{-2}\ K^{-4}$, T is the temperature of the lava (1523K), and T_c is the temperature of the surroundings. We also assume that the furniture we are stood on has a height of 1m and that the lava is contained within an area of $1m^2$. This gives us a value for P of $2.75 \times 10^5\ W$ which is equal to $2.75 \times 10^5\ J\ s^{-1}$.

The next step is to calculate the change in temperature per second above the lava, and thus determine how long one would be able to play the game for. We know that:

$$Energy\ per\ second = mc\Delta T\ per\ second \qquad (3)$$

So, assuming that the mass of the player is 70kg, we can use this to calculate a change in temperature (ΔT) of $3.89\ K\ s^{-1}$. This tells us that it would only be a matter of seconds before the temperature increases to such a point that the game is interrupted by the death of the players.

However, these calculations do not account for convection currents, which would play a large role as the participants are moving around directly above the lava. The existence of convection currents means that there would be a much higher temperature change above the lava than predicted here. The convection currents also account for the large number of photographs of geologists and rock enthusiasts who are stood relatively close to lava as the heat dissipates quickly near the edges.

Conclusion

In conclusion, from our calculations, we can see that it would not be possible to play a game of 'the floor is lava' either indoors or outdoors for more than a few seconds due to the large air temperatures produced above the lava. However, the authors of this paper do believe that it may be possible to play a short game of 'the walls are lava' if convection currents are taken into account, as long as the room it is being played in does not have a ceiling and participants attempt to inhale as few of the gases as possible.

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