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A1 4 Can I Pet That Dog?

A. Poole, S. Bourne, E. Stedall, R. Wass

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

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Abstract

This paper demonstrates a study of the seismological impacts of Entei's bark power from the world of Pokémon. We find that an energy of 3.23×10^{20} J is released in a 1 second bark, an output powerful enough to level cities and cause massive destruction.

Introduction

In the world of Pokémon, there are more than 1000 different monsters to meet, many of which possess abilities that could cause world-wide catastrophes. This paper aims to look into one Pokémon in particular, known as Entei. Appropriately referred to as the 'Volcano Pokémon', Entei's Pokédex entry states: "Volcanoes erupt when it barks. Unable to restrain its extreme power, it races headlong around the land." [1] This entry, from Pokémon Gold, is from the game first introducing Entei as a Pokémon. As this entry is unspecific, we can choose two scenarios for our calculations. We will choose to have a volcano at 1 km distance from Entei, and a second volcano at the antipodal point of the Earth to the Pokémon.

Theory

For a volcano to erupt due to seismic activity, it must be active, which we shall assume for both of our scenarios. In order to trigger the eruption, the volcano must experience a seismic event between magnitude 5.0 and 7.5 [2]. Since we are looking for the minimum energy required to cause an eruption, we shall use a magnitude 5.0 earthquake for the remainder of this paper. We shall also use sound waves and seismic waves interchangeably in this paper, as we are using P-waves throughout this paper, and so they shall be treated the same as sound waves, despite a change in medium. We will also treat Entei as a point source, with the sound waves of its bark travelling spherically. At a distance r from a point source, the intensity I_{min} is

$$I_{min} = \frac{P}{4\pi r^2} \tag{1}$$

where P is the power of the bark [3]. We will use this equation to find the power generated by Entei in a 1 second bark. In realistic seismology, the waves emitted will attenuate due to anelasticity, requiring a higher power output from Entei in order to reach the intensity needed to cause an eruption. Intensity will decay exponentially with the attenuation coefficient α, which will modify equation (1) to give us the following equation [4,5]:

$$I_{min} = \frac{P}{4\pi r^2} e^{-\alpha r} \tag{2}$$

where α is defined by

$$\alpha = \frac{\pi f}{Q v} \tag{3}$$

and has units of m^{-1}. f is the frequency, Q is the quality factor, and v is the velocity of the wave.

Results

To determine the power required by Entei to cause a volcanic eruption at a distance of 1 km, we can rearrange equation (1), setting r_1 at 1000 m, and giving the equation:

$$P_1 = 4.00 \times 10^6 \pi I_{min}. \tag{4}$$

For the volcano on the opposite side of the Earth, we will use the same equation, but setting r_2 as 1.27×10^7 m, to give a P_2 value of

$$P_2 = 6.45 \times 10^{14} \pi I_{min} \tag{5}$$

where I_{min} is the same value for both volcanoes. We can take these values to find a ratio of powers, and so we can divide equation (5) by equation (4) to find a ratio of approximately 1.62×10^8. Therefore the bark aimed at the antipodal volcano must be 162 million times stronger than the volcano at a distance of 1 km.

As clarified earlier in the paper, we will be using a power of a magnitude 5 earthquake to trigger this volcanic eruption. This is equivalent to approximately 2.00×10^{12} J, which we shall take to be P_1, assuming a 1 second bark to allow the power to be equivalent to the energy, and the ratio of powers will provide a P_2 value of 3.23×10^{20} W, which is equal to 3.23×10^{20} J, or a magnitude 10.5 earthquake.

To accommodate for realism in the paper, we can use our edited equation that includes seismic attenuation to see how much power would truly be required to trigger a volcanic eruption at the antipodal point. Equation (2) requires a value for α, which we can use equation (3) to find. Using a quality factor of 750 [6], a frequency of 5 Hz, taken as an average frequency of a P-wave [7], and wave speed of 8000 m s^{-1}, which has been taken as an average from the table seen in reference [8], we obtain an α value of 2.62×10^{-6} m^{-1}. We can use this value and the values of r_1 and r_2 to find a new ratio accounting for attenuation using equation (2) to obtain a value of 4.46×10^{22}. This new ratio can be used to alter our value of P_2 to give 8.89×10^{34} W. A power output this high is equivalent to a magnitude 20.1 earthquake, or 2.12×10^{25} tons of TNT.

Discussion

By applying attenuation to our values, Entei emits a 1 second bark with energy 8.89×10^{34} J, a massive amount of energy. Given the gravitational binding energy of Earth to be approximately 2.24×10^{32} J [9], this bark has the potential to disintegrate the Earth, spewing a cloud of debris across the Solar System. Due to the Pokémon world still existing, it is safe to assume there are some differences in this universe towards the laws of physics. If we ignore attenuation, we can drastically reduce the outcome of this release of energy, bringing our final output down to 3.23×10^{20} J. This value, while much lower, is still massive enough to match an earthquake of magnitude 10.5, a shock that would level cities and cause massive destruction around the globe. We can safely assume from these results that the Pokémon universe is fictional in nature, and so these power outputs most likely would not occur from Entei barking.

Conclusion

This paper discloses the energy released by a 1 second bark from the 'Volcano Pokémon' Entei. It is shown that the minimum energy needed to cause a volcanic eruption on the opposite side of the Earth is 8.89×10^{34} J if we include attenuation for a realistic approach. Excluding attenuation, our energy output drops to 3.23×10^{20} J, a much lower, yet still massively destructive release of energy, overpowering even the strongest earthquake recorded on Earth.

References

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