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# P3_7 Journey to the Centre of the Earth

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**Abstract**

In this paper we investigate how far down a tunnel directly towards the centre of the Earth a human could get and survive. This is calculated to be 1.17 km for a tunnel beginning in the UK. We then calculate how far a human could go on their journey to the centre of the Earth inside a refrigerator that maintains an air temperature of 20°C within it using the power generated by all of the on- and offshore wind farms in the UK. We found the temperature that could be reached is 46526 K, so the distance reached is ∼3977.8 km, due to the melting point of the fridge.

## Introduction

In the book 'Journey to the Centre of the Earth', the main characters travel to the centre of the Earth through volcanic tubes [1]. However a human could not survive travelling through the mantle and due to the temperature increase with depth, could not even travel a distance the same as the thickness of the Earth's crust. We have investigated how far a human could actually travel down a tunnel towards the centre of the Earth before the temperature becomes impossible to survive. We then calculated how much further a human could journey towards the centre of the Earth in a 'fridge' that cools the air inside to room temperature using a maximum power of 22002 MW (the operational capacity of wind farms in the UK) [7].

## Theory and Results

We assume a human can survive a temperature of up to 38 °C with a maximum humidity of 50% for 1 day from source [2], before the body is unable to cool itself down. The temperature gradient within a depth of 3-5 km from Earth's surface in continental crust is ∼25 °C km$^{-1}$ [3]. and the average surface temperature in the UK is 8.85 °C [4]. Therefore, for a tunnel in the UK, a human could survive travelling a distance of upto about 1.17 km into Earth's crust.

We then find the depth a human can travel in a spherical 'fridge' which cools the air inside to 20 °C.

The power used to cool the fridge ($P_c$) is the product of the input power ($P_i$) and the Carnot efficiency of the fridge ($K_{Carnot}$), which can be calculated using the following equation:

$$P_c = P_i K_{Carnot} = \frac{P_i T_C}{T_H - T_C}, \quad (1)$$

where $T_C$ is the temperature inside the fridge (20°C) and $T_H$ is the temperature of the Earth at the depth of the fridge.

The rate that heat energy is transferred to the interior of the fridge from the surrounding crust can be calculated using the equation:

$$\frac{dQ}{dt} = \frac{4\pi k r_1 r_2 (T_H - T_C)}{d}, \quad (2)$$

where $\frac{dQ}{dt}$ is the rate of heat transfer across the wall of the sphere, $k$ is the thermal conductivity of the wall, $r_1$ is the radius of the inside of the spherical shell, $r_2$ is the total radius of the sphere and $d$ is the thickness of the wall of the 'fridge'.

For a constant temperature to be maintained inside the sphere, $\frac{dQ}{dt}$ must be equal to $P_c$. The maximum external temperature, at which the fridge is able to maintain an internal temperature of 20 °C, can therefore be found by combining equations 1 and 2 and solving the resulting quadratic to find the solution for $T_H$:

$$T_H = \frac{2T_C \pm \sqrt{\frac{P_i T_C d}{\pi k r_1 r_2}}}{2}. \quad (3)$$

We calculated $T_H$ for a sphere with an inner radius of 1.5 m ($r_1$), which is large enough to contain a standing human , wall thickness of 0.5 m ($d$) and total radius of 2 m ($r_2$). We have modelled the 'fridge' as being made of hafnium carbide (HfC), a ceramic, as this material has the highest measured melting point of 3958°C [5]. We have assumed the thermal conductivity ($k$) of HfC is 40 W $m^{-1}$ $K^{-1}$, which is the thermal conductivity at 1950 °C [6]. The maximum operating power ($P_i$) used (from wind farms in the UK) was 22002 MW, as this source of energy is renewable [7]. We found that the maximum temperature of the Earth that could be reached for the temperature inside the sphere to remain constant at 20°C would be 46526 K (greater than that at the Earth's centre [8]), so the distance that can be reached is ∼3977.8 km (the distance at which HfC melts) [3].

## Discussion

Before a human or human in a 'fridge' could journey to Earth's centre, a tunnel would need to be drilled. A mechanism for lowering the human or 'fridge' into and out of this tunnel would also need to be built. This means the total power needed for the journey will be much greater than the power needed for the refrigerator alone. The 'fridge' would need to contain enough oxygen for a human to breathe throughout the duration of the journey into and out of the crust, allowing them to survive. We have assumed that the air temperature in the tunnel is the same as the temperature of the surrounding crust. The thermal conductivity of hafnium carbide would increase with temperature so this would affect our result [6]. The geothermal gradient will decrease with depth and can vary slightly depending on location.

## Conclusion

We found that a human could only survive a relatively short distance into the crust compared with Earth's radius of 6371 km.[8] As HfC, the material with the highest measured melting point, has a melting point lower than the temperature at the top of Earth's inner core (5000 K), it is impossible for a human to reach the centre of the Earth [3][8]. We find that, the all the wind power produced in the UK, the distance a human could get in a fridge that maintains an internal temperature of 20°C with our chosen dimensions would be limited by the melting point of HfC.

## References


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