

GEOTHERMAL ENERGY LOSS DUE TO HEAT CONDUCTION

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Reference: Daniel V. Schroeder, *An Introduction to Thermal Physics*, (Addison-Wesley, 2000) - Problem 1.61.

The temperature of the Earth increases as we go further underground so, given that the rock that makes up the Earth's crust has a thermal conductivity and there is a temperature difference between a point underground and the Earth's surface, the Earth is actually losing energy by heat conduction. Using the values given by Schroeder, we have $\Delta T = 0.02 \text{ K m}^{-1}$ and $k_t = 2.5 \text{ W m}^{-1}\text{K}^{-1}$. The rate of heat conduction in an area of 1 m^2 is therefore

$$\begin{aligned} (1) \quad \frac{Q}{\Delta t} &= -k_t A \frac{T_2 - T_1}{\Delta x} \\ (2) \quad &= (2.5)(1) \frac{0.02}{1} \\ (3) \quad &= 0.05 \text{ W} \end{aligned}$$

Although the rate of heat loss is quite small for a square metre, if we assume this value applies over the entire Earth (radius 6400 km), the total heat loss is

$$(4) \quad \frac{Q_{tot}}{\Delta t} = 4\pi (6.4 \times 10^6)^2 (0.05) = 2.57 \times 10^{13} \text{ W}$$

Although this sounds like a lot, to put it in perspective, the sun's luminosity is $3.839 \times 10^{26} \text{ W}$, and the peak energy received on Earth from the Sun is around 1365 W m^{-2} , which is around 27,000 times the rate at which the geothermal energy is being lost.