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A4_ 15 Conditions of the Mariana Trench

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Abstract

This article discusses the conditions at the deepest part of the world's oceans, the Challenger Deep located in the Mariana Trench. It was found that any creature surviving at this depth would have to withstand 1000 times the surface pressure and exist without light from the Sun as it cannot penetrate to this depth.

Introduction

The Mariana Trench contains the Challenger Deep, the deepest portion of the Earths Ocean. The reason for its extreme depth is due to its location. The Mariana Trench is above two converging lithospheric plates which collide with each other. This collision forces one of these plates into the mantle, the line of contact then forms a trough known as an Ocean trench [1]. At this depth then exists one of the most extreme environments on the surface of the Earth, however it has been suggested that life is present at its depths.

This article investigates the living conditions at the darkest depths of the Challenger Deep. The extreme environment is quantified by calculating the pressure at the bottom of the trench and the amount of light that can reach this depth.

Under Pressure

The most significant variance from the surface dwellers and the fish that survive in the depths of the Ocean is the change in pressure. Pressure changes much more rapidly in water, simply due to the weight of the water above being much higher than the air above the surface. The deepest portion of the Mariana Trench is known as the Challenger Deep, after the Royal Navy survey ship HMS Challenger whose expedition made the first recordings of its depth [2]. The maximum recorded depth of the Challenger Deep is 10.916km [3], so equation 1 is used to calculate the pressure P at this depth,

$$P = \rho g H, \qquad (1)$$

In which ρ is the density of the fluid and H the depth. However, when considering the pressure at the bottom of the Ocean one must also consider the atmospheric pressure on the surface of the Ocean itself. Thus,

$$P = P_{Ocean} + P_{atmopsheric}, \qquad (2)$$

as the total pressure on the bottom of the ocean is the sum of the pressure exerted on the surface of the ocean by the atmosphere ($P_{atmospheric}$) which is $1.01\text{x}10^5$ Pa and the pressure exerted on the ocean floor due to the ocean itself (P_{Ocean}).

The Mariana Trench is an ocean and thus consists of salt water. So combining equation 1 and equation 2 gives the expression for the pressure at the depth of the Challenger Deep;

$$P = \rho_{seawater} g H + P_{atmospheric}, \qquad (3)$$

in which g is the acceleration due to gravity, 9.81m/s^2, H the depth of the Ocean measured as 10.916km [3] and $\rho_{seawater}$ the density of seawater, 1030 kg/m^3 [4]. The density of seawater is given as a constant value, however it should be noted that this is not strictly true the density of seawater will increase at lower depths due to the increase in pressure and colder temperatures, but, using the value quoted above is sufficient for the purposes of this paper as the variance is very small (approximately 1%). This calculates the pressure at the ocean floor of the Challenger Deep as approximately $1.10\text{x}10^8$

Pa, over 1000x that of the pressure at the surface of the Earth.

Any Light Down There?

The second most significant difference between the surface and the deeps of the Mariana Trench is the amount of light present. The intensity of light from the Sun incident on the surface of the Earth is approximately 1380 W/m^2 [5]. However how deep would this penetrate into the Mariana trench, and would there be any light at the ocean floor? To calculate the deepest that light can penetrate (the optical depth) a simple analogy is used. Light will only penetrate a certain distance S due to the opacity (which is frequency dependant) κ_υ of water (values were found for pure water only). It will penetrate until the value of the optical depth τ=1(refer to figure 1). The relationship that describes this is approximately,

$$\tau \simeq \kappa_\upsilon S \,, \qquad (4)$$

thus the deepest light can penetrate (at which τ=1) is at an approximate distance of 1/ κ_υ.

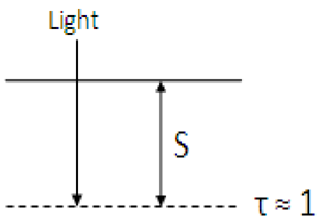

Figure 1; Diagram describing the relationship between the distance light can penetrate (S) and the optical depth (τ)

The opacity of visible light is highly dependent on the frequency of the light, with reference to figure 2 it is clear that the most penetrative colour is in the blue/violet range of visible light at an approximate wavelength of 400nm.

At this wavelength (and corresponding frequency) the opacity of water is approximately $1\text{x}10^{-2}\text{m}^{-1}$ [6]. Thus the maximum distance that light can penetrate into water,

$$S \simeq \frac{1}{\kappa_\upsilon} = 100\ m \,, \qquad (5)$$

thus at the deepest depth of the Challenger Deep (10.916 km) there will be no light present and then in complete darkness.

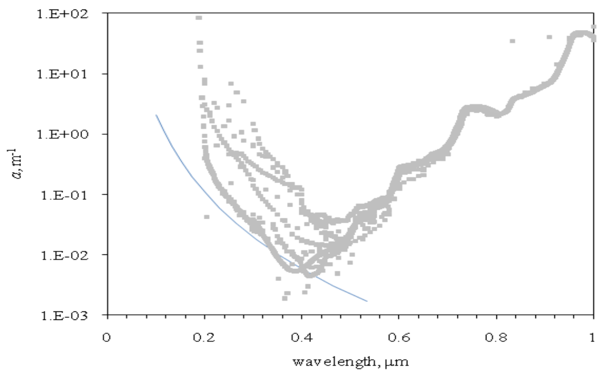

Figure 2; Absorption of light in the visible and near infrared range [6]

Conclusions

This article describes the conditions at the deepest part of the Mariana Trench, known as the Challenger Deep. At this depth it was found that any creature surviving in this extreme environment would need to withstand over 1000x the surface pressure at a pressure of $1.10\text{x}10^8$ Pa and live in complete darkness, as no light from the surface could penetrate this depth.

References

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[5]http://www.astronomynotes.com/starsun/s2.htm (30/11/11)

[6]http://www.tpdsci.com/tpc/AbsCfOfWaterVisAllFig.php (30/11/11)