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A1 6 See You Crater, Planet Earth!

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Abstract

In this paper we investigate the damage caused to the planet Earth due to the collision of the asteroid in the film Armageddon. Continuing previous work [1], we used our previous transient crater value of 7346 km to find the final diameter of 23505 km with the knowledge that the impact would result in the formation of a complex crater with a range of depths between 1175.3 km and 2350.5 km. Using a simple conversion we found that the kinetic energy imparted onto the Earth to be 1.34×10^{29} J during the impact event, a value that is almost half a million times greater than that for the impact that killed the dinosaurs.

Introduction

This paper is a continuation in a series of papers analysing the science behind the film Armageddon. In our previous work, we determined that the diameter of the transient crater formed by the Armageddon asteroid (D_{tc}) would have a value of 7346 km [1]. However the transient crater is only an ephemeral initial state for an impact basin; with the final size often being much larger. We intend to determine what type of final crater this impact event would have created and evaluate both its physical properties and the potential damage it could cause to Earth.

In the case of crater morphology, there are two main categories: simple and complex. Simple craters are the smaller of the two and, depending on the gravitational effects of the body, are commonly only just a few kilometres in size [2]. They are bowl-shaped depressions with smooth sloping sides and rather circular rims (Figure 1). Complex craters, however, are on a much larger scale. During their formation, this crater type has a much longer modification stage - the final stage in crater formation that is governed by the gravitational influences of the body. Unlike with simple craters, the modification stage causes the formation of terraced walls and central peaks [2] (Figure 2). These craters are far shallower than their counterparts but span tens to hundreds of kilometres in diameter. To determine which type of crater that will form, two parameters must be considered. First, the value at which a simple crater becomes a complex crater - this is dependent on the body that is being impacted. Secondly, and most importantly, the size of the impactor. If your impactor creates a transient crater that is larger than the simple-to-complex transition, then the final crater will be complex.

Impact Basin Characteristics

On the Earth, the boundary at which a basin forms as a complex crater as opposed to simple (D_{sc}) is at 3.2 km [2]. Since our transient crater (and impactor) is orders of magnitude larger than this, we can be confident that it will

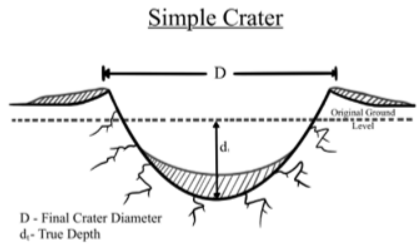

Figure 1: Characteristics of a simple crater.

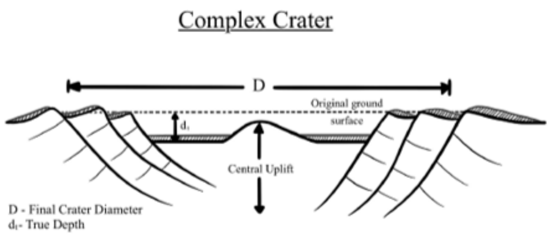

Figure 2: Characteristics of a complex crater.

be complex when it has reached its full size. The diameter of a complex crater (D_{cc}) is typically determined using the following relationship [2]:

$$D_{cc} = 1.17 \left(\frac{D_{tc}^{1.13}}{D_{sc}^{0.13}} \right) \tag{1}$$

This grants us $D_{cc} = 23505$ km, which is extremely large when considered in the context that Earth's diameter is only around half of this value; though this is an unprecedented scale of impact. The largest confirmed impact basin in the solar system is the Utopia region of Mars, with a crater diameter of 3300 km [3]. We can also determine the depth of this crater; a typical complex crater has a depth:diameter ratio between 1:20 and 1:10 [4]. Here that grants depth values between 1175.3 km and 2350.5 km. This crater would reach down into the lower mantle and would likely cause magma to engulf the planet's surface.

Damage

The collision of an enormous object ($D = 1250$ km [1]) travelling at speeds (v_i) of 9.83 km/s [1] will impart huge amounts of energy to the planet. To calculate this we take $KE = \frac{1}{2}mv^2$ and approximate our asteroid mass (m) using $m = \rho V$, where V is the volume of a sphere: $V = \frac{4}{3}\pi(\frac{D}{2})^3$.

$$\therefore KE = \frac{1}{12}\rho_p \pi D^3 v_i^2 \tag{2}$$

Therefore, for our crater (which was previously found to have a density of $\rho_p = 2.71$ g/cm^3 [1]), we find an energy of 1.34×10^{29} J imparted onto the Earth. This is almost half a million times more energetic than the Chicxulub impact event which caused the Cretaceous-Paleogene mass extinction and was the previous largest impact event on Earth [5]. This caused side effects such as: earthquakes, magma flows, multiple years of global ash clouds, wildfires, and many other repercussions.

Conclusion

In conclusion, the final crater left behind by such a violent impact would result in a large amount of kinetic energy being transferred into the planet, 1.34×10^{29} J. After an extensive modification stage, the crater left behind would be complex in nature and 23505 km in diameter. This is almost twice the diameter of the Earth, therefore it would be safe to say that the 'global killer' asteroid would result in the ultimate demise of the planet. It would most likely be fragmented and potentially result in the formation of thousands of new asteroids within the inner Solar System which would wreak havoc on the planets that reside there.

References

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