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A4_1 Meteor nuking

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Abstract

This article looks at the possibility of destroying a meteorite that would otherwise cause mass extinction on Earth by using nuclear missiles. The conclusion arrived at is that the amount of energy required to achieve this is far out of the range of any weapons available to humanity and so the approach is gravely flawed and could not realistically be used.

Introduction

Celestial objects come in many different In many works of science fiction, a meteor is heading for Earth and humanity is eventually saved by deploying at least one nuclear weapon in order to destroy the object. This is normally achieved by either placing a nuclear warhead inside the meteor somehow and detonating it or firing a salvo of missiles in the hope of destroying it. This article will consider the possibility of destroying the meteor using explosives.

Assumptions about the meteor

Celestial objects come in many different sizes, shapes and compositions, but the assumption here is that the meteor will have a composition comparable to asteroids in the belt between Mars and Jupiter and it shall be large enough to cause mass extinction on Earth.

The Chicxulub crater is a 100 km wide crater [1] in Mexico that is thought by many to be the impact site of the meteor that is responsible for the K – T extinction (the event which led to the extinction of the dinosaurs among others). It has been estimated that the object which impacted at this site had a diameter of 15 km [1], so we shall assume this size for the meteor.

Looking at objects in the asteroid belt between Mars and Jupiter, the most common compositions involve either a high carbon, silicon or iron content [2], so for the purposes of what follows we shall consider a core made up of silicon dioxide (sand, SiO_2).

For the purposes of the discussion here, let us assume that to destroy the asteroid, we wish to completely atomise it. The question to then ask is how much energy is required to do this?

How much energy?

We shall assume that our meteor is spherical and as such we need the formula given in (1) for the volume of a sphere, where V is the volume and r the radius of the sphere.

$$V=\frac{4}{3}\pi r^3 \quad . \qquad (1)$$

This means that the volume of the meteor is about 1.77×10^{12} m^3. The density of silicon dioxide is about 2.65 gcm^{-3} [3] and it is thus possible to calculate the mass of the meteor, which turns out to be approximately 4.69×10^{15} kg. SiO_2 has a molar mass of 60 $gmol^{-1}$ and so the meteor represents 7.82×10^{16} moles.

In order to calculate the total amount of energy required to destroy the meteor, we need to know the bond enthalpy (amount of energy required to break the bonds). For SiO_2 it is 622 $kJmol^{-1}$ [3]. Multiplying this number by the 2 (there are two such bonds for each molecule of SiO_2) and then by the number of moles should generate the final amount of energy required. This number turns out to be approximately 9.73×10^{22} J.

Discussion

The number quoted above as the amount of energy required to destroy a meteor is perhaps better put into context. The explosive yield of a nuclear bomb is often quoted in tons (or kilotons, megatons etc.) of TNT, with a ton of TNT releasing 4.2×10^{9} J of energy [4]. Thus, it is possible to calculate that the required explosive yield would have to be 2.3×10^{7} megatons. The largest warhead ever tested was 50 megatons. This is a factor of 463000 smaller.

It should be noted at this point that the above calculation is a simplification that leaves many issues untouched. You would not need to completely destroy the meteor in order for it to cease being a threat. All you would need to do is reduce the object to chunks that were too small to survive entry into the Earth's atmosphere. This would reduce the explosive power required. It also ignores how the weapon(s) used for the venture would be deployed, but if anything this only complicates the issue, making it even more difficult.

Conclusion

With the energy required to destroy an incoming meteor of the scale necessary to cause mass extinctions being hundreds of thousands of times greater than the largest nuclear device ever detonated on Earth, it can be seen that it would be unlikely that such an approach would ever be successful. This completely ignores other approaches involving explosives (such as diverting the meteor, but such discussion is beyond the remit of this article.

References

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