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QUANTIFYING THE EMISSIONS PER KG MASS RETURNED FROM AN ASTEROID MINING MISSION

Abstract

Space is becoming more accessible for industrialisation, and it is becoming increasingly clear that the modern world must be environmentally vigilant. The global approach towards the inevitable mining of asteroids must be sustainable and beneficial, to society and the environment. Proponents of asteroid mining suggest there is an environmental benefit in reducing the carbon emissions produced from terrestrial mining processes. However, asteroid mining may also have negative environmental impacts in the CO_2 and other particulates produced from the exhaust plumes of rockets required to place spacecraft and mining equipment into space. This paper investigates the comparison of the environmental impact of the two approaches in the context of Platinum Group Metals (PGMs), with an aim to quantify the number of asteroids in the Near-Earth Asteroid (NEA) and Main-Belt Asteroid (MBA) group that provide net environmental benefits, when compared to the typical equivalent terrestrial mines. This is done by first calculating the fuel emitted in the atmosphere for Falcon Heavy to launch to a 200km parking orbit with the payloads required for a transportation spacecraft to propel itself to the target asteroid, then finding the total return mass possible for each asteroid. Calculations are based upon Δ V calculated using the Shoemaker-Helin equations. The fuel emitted into the atmosphere is then converted to CO_2e units using emission indexes to find the mass emitted for each component, then multiplying by their Global Warming Potentials (GWP). The total CO_2e emissions for the launch and the return mass are used to find the emission ratio, which is compared to the emissions for terrestrial mines. It is found that 84% of NEAs could be environmentally beneficial, while 36% of MBAs could be environmentally beneficial. Using estimates from literature on the proportion of asteroids represented by M-Type asteroids, it is found that 1.4-2.9% of MBAs and 3.4-6.7% of NEAs are both (potentially) environmentally beneficial and M-Type asteroids. The difference between emission rates of asteroid mining and terrestrial mines is lower than expected, and it is found that this is likely due to the extreme GWP of tropospheric Black Carbon. It is suggested that further research is conducted to confirm these predictions, and regulation is called for to monitor the effects of rocket launches on the environment.