# Asteroid Mining: Science Fiction or Future Source of Raw Materials?

By Rainer Zitelmann November 14, 2024

NASA Hubble Space Telescope

Asteroids not only represent a potential threat to humanity, they also offer great opportunities, especially for the future. Current estimates suggest that there are between 700,000 and 1,700,000 asteroids with a diameter of at least 1 kilometer. The majority of these asteroids are located within the asteroid belt between Mars and Jupiter. However, there are also approximately 34,000 known near-Earth asteroids (NEAs) – and around 2,000 to 3,000 more are discovered every year. Some of these can be a threat, others present valuable opportunities.

The media sometimes covers stories about asteroids, such as Psyche, a celestial body with a diameter of 250 kilometers, larger than the area of England. The value of this asteroid has been estimated at up to 700 trillion dollars due to suspected large deposits of precious platinum-group metals (PGMs). However, some scientists have recently raised doubts about these estimates. And of course, these prices could never be achieved if the market were flooded with large quantities of such metals. We will know more in 2029 when NASA's Psyche probe, launched last year, reaches the asteroid with which it shares its name.

The fact is, however, that valuable raw materials such as PGMs are found in much higher concentrations on some asteroids than on Earth. We know from the analysis of meteorites that the concentration of PGMs, at 6 to 230 ppm, can be many times greater than those found in the Earth's crust. This is because most asteroids never experienced the 'differentiation' that took place on planets such as the Earth. Differentiation is the process by which heavier materials, such as metals, gravitate towards the core of a celestial body, while lighter materials, such as silicates, form the outer layers.

As soon as you start to discuss the topic of asteroid mining, you quickly realize that there are many common misconceptions. One is the belief that asteroids are too far away, that the distances are too great. However, leading expert John S. Lewis estimates that there are around 3,800 near-Earth asteroids (NEAs) that are more accessible and require less fuel to reach than the moon.

You also often hear that the cost of transporting extracted raw materials is so high that mining them makes no economic sense. Of course, this is partly true, but it misses the point. Experts such as Lewis, who first addressed this topic in his 1997 book *Mining the Sky*, argue in favor of using the raw materials mined from asteroids in space. For instance, numerous asteroids contain water, which can be harvested and separated into hydrogen and oxygen to serve as rocket fuel. Raw materials from asteroids can also be used to build space stations or large solar panels in space.

Furthermore, thanks to the emergence of private space travel, the cost of transporting materials into space has fallen dramatically, by an estimated 80 percent. This cost reduction is largely due to SpaceX, combined with innovations in reusable rocket technology, a technology that is still relatively immature. And these developments naturally have a significant impact on the profitability of asteroid mining.

Movies like *Armageddon*, which show Bruce Willis and his team bringing super-heavy drilling machines onto an asteroid, have distorted the way we think about these celestial bodies. In fact, many asteroids are nothing more than flying piles of rubble, the material barely sticking together due to an almost complete lack of gravity. In many cases, crushing rocks with heavy equipment is not even necessary. On the

lack of gravity. In many cases, crushing rocks with heavy equipment is not even necessary. On the contrary, the real problems lie elsewhere, such as dealing with the challenges of landing on small piles of rubble, or finding a way to securely anchor a spaceship or mining equipment. These tasks are more feasible on larger asteroids. And when mining starts, there's also the problem of materials floating off into space due to the lack of gravity.

But there are solutions for that, too. The cable-cutter bag principle, developed by NASA in the 1990s, aims to efficiently collect material from asteroids. A net or bag is stretched over the asteroid's surface, using cables and cutting devices to enclose and secure rock samples. This method allows for the controlled and safe collection of samples without complex anchoring or drilling mechanisms, which is particularly advantageous in microgravity.

Some people also argue that the legal framework for asteroid mining is inadequate, but this is also only partially true. Yes, the Outer Space Treaty of 1967, which has been ratified by 116 nations, does prohibit the ownership of "celestial bodies" (although the term is not clearly defined and there is debate among legal experts as to whether it includes smaller asteroids). In contrast, the U.S. Commercial Launch Competitiveness Act of 2015 does allow Americans to engage in the commercial exploitation of space resources. Luxembourg has a similar law.

Several companies are currently engaged in the field. One company, AstroForge, is planning to launch a 200kg spacecraft to an asteroid in 2025 to analyze its composition. Other companies, such as Karman+, are pioneering the technique of optical mining, which uses directed sunlight to heat and break down rocks in space. This would allow valuable resources such as water and metals to be extracted from asteroids.

Asteroid mining is still in its infancy, but has the potential to become a major industry over the next few decades, especially as it is far too expensive to transport large quantities of propellants and other materials into space, even as costs continue to plummet. "On-site" production therefore makes much more sense.

This is the abbreviated version of a speech given at the 8th Raw Materials Congress of the Federation of German Industries on November 11, 2024 in Berlin.

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