

# **REPORT 1**

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## **Asteroid Mining**

The concept of asteroid mining has gained increasing attention following the detection of a newly discovered asteroid approximately 10 meters in length, observed through a high-powered telescope in Sutherland, South Africa. This discovery, documented in the *Research Notes of the American Astronomical Society*, has renewed discussions around the feasibility of harvesting extraterrestrial resources, particularly from asteroids. Asteroid mining refers to the process of extracting valuable materials such as metals and water from minor celestial bodies. Scientists believe that many asteroids contain abundant deposits of elements like platinum, gold, and nickel, as well as vital resources like water, which could support future space missions or even off-Earth industrial activity.

However, this venture is not without its complexities. The distance to reach asteroids, especially those beyond Earth's orbit, poses a significant challenge, with missions to Mars alone taking roughly eight months under optimal conditions. Given these constraints, most proposed asteroid mining operations are designed around robotic missions to prioritize cargo space and avoid the complications of human life support. Launching from Earth is another major hurdle due to its strong gravitational pull, making it more energy-efficient to conduct launches from low-gravity celestial bodies such as the Moon or Mars. Additionally, transporting raw materials back to Earth is risky and expensive, suggesting that in-space refining and only returning finished products could be a more viable strategy.

Despite these challenges, asteroid mining offers remarkable opportunities. Certain asteroids, like 16 Psyche, are believed to contain metals worth up to \$700 quintillion, presenting unimaginable financial potential. Unlike terrestrial mining, space-based extraction avoids environmental damage such as water pollution and toxic chemical exposure. It could also play a role in developing solar power satellites and addressing global water shortages. Moreover, asteroid mining could reduce dependence on unethical labor practices often associated with mining in developing regions, including the use of child labor in the Democratic Republic of the Congo.

Economically, the implications of asteroid mining are profound. Experts like Neil deGrasse Tyson have speculated that the first trillionaire could emerge from this industry. Yet, the sudden availability of vast quantities of precious metals might cause dramatic market disruptions, severely devaluing similar Earth-based resources. Countries that depend heavily on mineral exports could face economic instability or collapse. Traditional mining jobs, especially those requiring low skills, may become obsolete, potentially displacing large segments of the workforce.

## **Spectroscopy**

Spectroscopy is a scientific technique that investigates how matter interacts with electromagnetic radiation. It allows researchers to uncover detailed information about the structure, composition, and physical characteristics of substances. By examining how light is absorbed, emitted, or scattered

by a material, scientists can identify the types of atoms or molecules present. Spectroscopy is widely used in disciplines ranging from chemistry and physics to astronomy and materials science, as it enables the analysis of substances without altering or destroying the samples being studied.

Historically, the roots of spectroscopy trace back to Isaac Newton, who first split white light into its component colors using a glass prism. Over time, the field developed in tandem with atomic theory and quantum mechanics, leading to the emergence of highly specialized tools and methods. Today, spectroscopy includes modern techniques such as laser spectroscopy, Fourier transform spectrometers, and sophisticated instruments used on space telescopes.

The basic principle behind spectroscopy lies in the fact that each atom or molecule interacts with light in a unique way. These interactions produce a spectrum that acts like a fingerprint, allowing identification of the substance. Depending on the type of spectroscopy, this spectrum may display patterns of absorption or emission lines. Devices called spectrometers measure these spectra by dispersing light into its component wavelengths and recording the resulting patterns.

Various forms of spectroscopy are employed depending on the context. Optical spectroscopy uses visible, ultraviolet, and infrared light to analyze materials. It includes methods such as absorption spectroscopy, emission spectroscopy, and fluorescence analysis. Atomic spectroscopy, on the other hand, focuses on how electrons transition between energy levels within atoms, giving insight into atomic structures. Molecular spectroscopy investigates how molecules interact with light, particularly in terms of vibration and rotation, helping scientists understand bonding and molecular geometry.

Other important types include X-ray spectroscopy, which studies inner electron transitions using high-energy radiation, and radio-frequency spectroscopy such as nuclear magnetic resonance (NMR), which explores the magnetic environments of atomic nuclei. Resonance ionization spectroscopy is a highly sensitive laser-based method used for detecting specific atoms or isotopes, often applied in environmental testing or nuclear research.

## Optical Spectrometer

An optical spectrometer is a fundamental tool used in spectroscopy to measure light properties such as wavelength, intensity, and sometimes polarization. It typically includes a component like a diffraction grating or a prism to disperse light, a slit and lens system to focus and channel the light, and detectors such as charge-coupled devices (CCDs) to capture the resulting spectra. Spectrometers come in various forms; for example, spectrophotometers measure light intensity, spectroradiometers evaluate optical power, and spectrum analyzers focus on microwave and radio frequency ranges. Spectrographs, a related instrument, record entire spectra and may be designed for high-resolution measurements, as in the case of echelle spectrographs, or for rapid imaging, as with slitless spectrographs used in solar studies.

## Raman Spectroscopy

A specific and highly valuable technique within the field is Raman spectroscopy. This method examines molecular vibrations by directing a focused laser beam onto a sample. While most of the laser light is scattered without energy change, a small portion experiences a shift in energy due to interaction with the molecules—this phenomenon is known as the Raman effect. By analyzing this

energy shift, scientists generate a Raman spectrum, which provides detailed information about the molecular structure and composition of the material. Because it is non-destructive and highly specific, Raman spectroscopy has applications in a variety of fields including medicine, materials science, and planetary exploration.