

Space: Getting Information on The Composition and Physical Structure of Asteroids

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Abstract

Asteroid mining has become an interesting area of research, both within scientific and business orientated focuses. Due to diminishing resources upon the Earth it is important to look for an imminent source of minerals in order to fuel the rapid growth of the population. Acquiring these resources is a difficult task and comes with many political and physically challenging problems, this paper will address potential methods for asteroid prospecting at a manufacturable scale that may be encountered over the foreseeable future.

Introduction

The very screen that this documentation is being read upon is at the demise of precious and scarce minerals such as Terbium and Neodymium. However, acquiring such minerals is devastating to the environment. The current methods being through mining, which is not only visually damaging but also causes great conflict with the ecosystems that occupy the landscape. This could potentially be through chemical leakage, releasing of toxic fumes and greenhouse gases which contribute to global warming. Politically, this causes issues as countries leverage their position based upon their mineral supplies and the very land that they situate. It has become increasingly appealing to remove such tensions through asteroid prospecting. A process of mineral exploitation on asteroids and minor planets.

Retrieving Information

Through the use of telescopic spectroscopy, which inherently measures the electromagnetic wave spectrum (most major frequencies being distributed within the visible light, radio and X-ray radiation) to scan celestial objects. Such information like the density, mass, temperature, chemical composition can be retrieved from an object. X-ray spectroscopy in particular can help to determine specific wavelengths emitted from hot gases and solid objects in particular through their emission and absorption lines. Asteroids, being in the cold desolate regions of space don't necessarily provide clear emission spectra. Nonetheless, this could be utilised to infer from neighbouring gases about the potential chemicals in unknown regions. Allowing for scientists to gain a relatively good approximation into the chemical makeup of an asteroid. Most of which are situated within three main C, S and M type categories, determining their composition. From here it becomes a merely simple

selective process based on the exact minerals that are required and the relative positioning of the asteroid given its orbiting conditions.

Strategies For Exploitation

Considering that the majority of asteroids are located within the asteroid belt and the Kuiper Belt, it would begin to seem feasible that these can be accessed. More so considering that space travel is becoming more accessible with the recent successes of privatised companies such as Space X and the Falcon 9 two stage rocket manufacture. It would be compelling for such company to enhance on their reusability factors that they have had such success with to retrieve samples and minerals. Relatively small asteroids can provide up to trillions of dollars worth of minerals and precious metals ,however at this point in time they are not accessible due to the sheer cost of transportation, manufacture, production and extrapolation from the current mining situations. Even getting within a low Earth orbit costs an extortionate amount of money by kilogram, this is without further consideration into the payload required to be carried for a physical mining process. Therefore, travelling to the region situated Mars and Jupiter or even to the Kuiper Belt (30 to 50 AU from the sun) out past Neptune is not feasible, a different process has to be considered.

A potential solution for the current day climate could be to utilise the reusable rockets to expel a cluster of deep space flight electrical propelled spacecraft. This will not only reduce the unnecessary associated fuel costs but will provide several opportunities at returning valuable resources. Once the relative velocities of the probes and orbiting distance match that of the near Earth asteroid there are several approaches that could be taken. Thrusters could provide precise directional changes, however this would need to be taken into account when initially calculating the power requirements. A cheaper and more practical plan of action could be through anchoring to the surface or perhaps even grappling. Once secured to the surface, drilling can take place in multiple phases on the predetermined locations where the minerals have been located. After the payload has been collected, the spacecraft can wait until a suitable maneuver point within orbit and safely bring the minerals back the Earth, deploying the traditional decelerative methods with heat shields and parachutes to increase drag once further in the atmosphere. A cluster of CubeSat like spacecraft exploiting a singular asteroid provides a great deal of precision and reduces the risk of precious metal/mineral loss if there was to be a mission threatening problem.

Instead of travelling to the asteroid itself it may be more beneficial to perform the rendezvous at closer orbit location and actually “tow” the asteroid into a stable near Earth orbit. This would be incredibly energy intensive and may require a singular chemically propelled engine and spacecraft. With this you also pose the risk of changing the asteroid orbit, potentially deviating it into collision with that of the Earth unintentionally. Nonetheless, this would make the retrieval and transportation back to Earth or an low Earth orbit collection

point much more feasible. It would not be suitable for manned missions to do such a job, the process would require far too much time, physically demanding work and supplies which would occupy space otherwise replaced by metals.

In both cases the machinery required to successfully mine the minerals will be unique to that situated upon Earth. Through the abundance of solar energy, the tools will be sufficiently powered to maintain the drilling process. There will need to be some suction based operation to prevent the grinded material from floating out into the vastness of space and such minerals will need to be filtered from any dead weight dust and debris. This could be done through a centrifuge, separating based upon density, but the efficiency of such a machine would not be the best. Chemically bonding during the centrifugal stage with a liquid solvent could be beneficial but the additional costs may not outweigh the benefits. Taking into consideration the fact that there will be a several multitudes worth of material mined in comparison to an Earth based ore, aiming for sustainability and efficiency may not be the best focus of energy at the beginning stages of development.

Scalability and Considerations

The time scale on these missions will be within the years due to our current technology, which in itself haults things. Production of the spacecraft could be done relatively cheaply and quickly due to their reproducible nature in comparison to tradition spacecraft however this will obviously require trialling and testing which takes decades. Governmentally, it would not be of the interest of the people to fund such missions and therefore it will be down to privatised companies, which run scarce in the space industry. Politically, this raises many queries. There are unfathomable amounts of money just sat waiting to be exploited in space, but what use is that if when you retrieve the asset and bring it back to Earth the economy collapses due to the onboard of thousands of years worth of collective material. As an advancement of a species, asteroid mining is the next stage in development. Limitations behind the monetary value of minerals could no longer be a factor into interplanetary terraforming and the substantial development of our infrastructure. It all comes down to human psychology and whether greed will triumph the potential scientific prosperity.