Resource Modelling for Mining on the Moon, Mars and Asteroids

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ABSTRACT

Motivations for Off-Earth Mining and Resource Utilisation include: 1. To provide in situ off-Earth resources for the expansion of human manned and robotic activities into space, and 2. To discover valuable materials on extra-terrestrial bodies and return these to Earth. As in terrestrial mining, these motivations lead to a strong requirement for prospecting, which is the initial identification of promising mineral deposits (e.g. water ice) on extraterrestrial solar system bodies. Extraterrestrial prospecting falls naturally into three phases: discovery (e.g. of asteroids by ground or space-based observatories); remote characterisation (by radar, photometry, ground or space-based IR spectroscopy, and comparisons of characterisation data with meteorites or terrestrial minerals); and local characterisation, including near fly-bys and landings for high resolution non-contact instruments or sample collection by landing. Prospecting data can be ingested and processed via automated and semi-automated analytical methods to produce three dimensional (3D) resource models. These analyses constitute a form of predictive analytics, where the target of prediction is the structure and material composition of an ore deposit and its host environment. Methods used for terrestrial resource modelling must be heavily adapted for use in off-Earth mining to take into account key differences between off Earth and terrestrial ore deposits and the methods needed to mine them, including some fundamental attributes in the case of small bodies that can be significantly shifted due to mining, such as gravitational vectors and magnitude distribution, and rotational parameters. These adapted models apply to resources on Mars, the Earth's Moon and small solar system bodies (asteroids and comets). A workflow model has been developed showing the derivation of resource characteristics and spatial distributions from incrementally more detailed characterisation data.